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AMERICAN JOURNAL OF SCIENCE

[FOURTH SERIES.]

ART. I.—*The Variation of Potential along the Transmitting Antenna in Wireless Telegraphy*; by C. A. CHANT.

I. *Introduction.*

IN a former paper* illustrations were given of the manner in which standing waves are formed on a free-ending wire when the electrical disturbance is produced by electrostatic induction from a Hertzian oscillator at the other end of the wire. The present communication contains a somewhat detailed account of an examination of the aërial wire used to radiate the waves in wireless telegraphy; and, in a section at the end, a brief account of a continuation of the former experiments.

The problem of the electrical oscillations about a free-ending wire has been treated from a rigid theoretical basis by Abraham,† who determined the electric and magnetic forces at any point in the field by directly integrating the Maxwellian equations. For the purposes of analysis the wire was considered to have the form of a very elongated paraboloid of revolution, and the field to vary in such a way that the electric lines of force ended perpendicular to its surface. Sarasin and de la Rive,‡ and others had compared the oscillations about a wire to those in an open pipe; but, as Abraham remarks, though the relations are essentially similar, the analogy must not be pushed too far, In the pipe the radiation is from within outwards, and is greatest in the direction of the

* C. A. Chant, The Variation of Potential along a Wire Transmitting Electric Waves; this Journal, xv, p. 54, 1903; Phil. Mag. [6], v, p. 331, 1903.

† M. Abraham, Ann. der Physik, ii, p. 32, 1900.

‡ E. Sarasin and L. de la Rive, Archives des Sciences Physiques et Naturelles, Genève, xxiii, p. 113, 1890.

axis; while in the electro-magnetic case the radiation is from without inwards, being limited by the surface of the wire, and on account of the transversality of the vibrations there is *no* radiation along the axis. Moreover, in the air-vibrations there is a displacement of the entire system of nodes and loops towards the open end, while, with the electrical oscillations, *to a first approximation*, there is no such displacement. On a closer examination, however, there is found to be a displacement of this kind, variable with the frequency. The phase of the advancing waves alters in a discontinuous manner, somewhat as in the vibrations of a plucked string.*

When two wires are used, as in Lecher's arrangement, the radiation in the direction of the axis does not vanish, and the analogy to the open pipe is more marked. There is then a decided displacement of the nodes and loops, well exhibited in an investigation by de Forest.†

The best acoustical analogy to a wire connected at one end to earth or to a large capacity and free at the other seems to be a closed pipe, gas-pressure in the pipe corresponding to potential or charge in the case of the wire. Here there is a displacement of the nodes and loops, but it is very small, and only the odd harmonics are present in the two cases. Of course a rod clamped at one end is similar to the closed pipe.

Birkeland and Sarasin,‡ in their investigation of the field about a free-ending wire, explored with a circular resonator, and found the first node distant from the end by one-half the circumference of the resonator (a result similar to that obtained by Sarasin and de la Rive in their investigation on two parallel wires, and ascribed by them to the geometrical form of the resonator), and other nodes regularly spaced along the wire at intervals equal to twice the diameter of the resonator. The form of the nodal surfaces in the space about the wire obtained by them agrees with that deduced by Abraham.

Slaby's theoretical treatment§ of the problem is much simpler than Abraham's, and from his results he was led to his method of syntonic telegraphy. He takes the so-called "telegraphic equation,"

$$R_1 \frac{\partial i}{\partial t} + L_1 \frac{\partial^2 i}{\partial t^2} = \frac{1}{C_1} \frac{\partial^2 i}{\partial x^2},$$

where i is the current strength at any time at a place x on the

* Helmholtz, Sensations of Tone, p. 54; Rayleigh, Theory of Sound, art. 146.

† L. de Forest, this Journal, viii, p. 58, 1899.

‡ K. Birkeland and E. Sarasin, Comptes Rendus, cxvii, p. 618, 1893.

§ A. Slaby, Lond. Electrician, vol. xlvi, Jan. 18, 1901; also vol. xlix, April 25, 1902.

antenna, and R_1, L_1, C_1, are the resistance, self-induction and capacity per unit length of the wire. A solution* is

$$i = A e^{-\frac{R}{2L}t} \cos \frac{2\pi}{T} t \sin \frac{\pi}{2l} x,$$

where $T = 4\sqrt{LC}$, l is length of wire, A is a constant and R, L, C, relate to the whole length of the wire. The frequency is $1/T$ and $\lambda = 4l$. From this solution it should follow that the disturbance varies according to the simple harmonic law, and that the free end of the wire is a potential loop, the lower end a potential node.

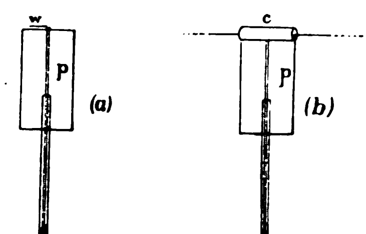
II. *Experimental Arrangements and Results.*

In the present investigation all the wires explored were of bare copper of diameter 7^{mm} and were stretched horizontally on the tops of wooden poles about $1{\cdot}5^{m}$ high and $1{\cdot}6^{m}$ from the wall of the room in which the experiments were made. This room was a large hall, on the first flat, about 22^{m} long, 12^{m} wide and with a ceiling 13^{m} high. The manner of examining the wire at various points in its length was precisely similar to that in the former research. The induction coil and interrupter, the magnetometer and the method of taking readings were identical with those used earlier and need not be described again here.

In most of the work the detector was the one used before, but during the course of the experiments it was broken and another, similar to it and indistinguishable from it in its behavior, was constructed.

The manner of applying the detector to the wire was slightly different. Before, the detector was laid on the top of a carriage moving on ways along the wires, with the little wing, *w*, fig. 1, in a little pocket by the wire; now, a small piece, *c*, of

1



cylindrical hard-rubber rod, in which a groove was made down to the axis, along a plane through the axis, was fastened to the

* See Webster, Electricity and Magnetism, arts. 255, 256.

hard-rubber plate, p, by wax, and the detector was then hung on the stretched wire at any place desired.

The curves are plotted from the mean of at least three sets of readings.

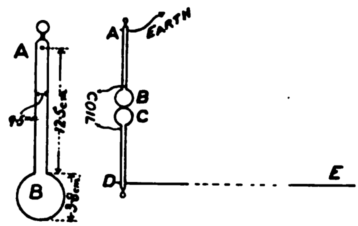
The published accounts of the exploration of wires about which electrical disturbances are produced as in wireless telegraphy are not numerous, and, as far as I can learn, in no case has the exploration been at all minute.

In the present investigation three methods, well-known in practice, have been used to excite the oscillations.

Marconi's Simple Method.

This arrangement is illustrated in fig. 2. The "oscillator" in this case consisted of two cylindrical brass rods, AB, CD, $9{\cdot}5^{mm}$ in diameter and $12{\cdot}5^{cms}$ long, ending in spherical knobs B, C, $3{\cdot}8^{cm}$ in diameter. One half of the doublet is shown on

2



a larger scale at the left-hand of fig. 2. From D led off the antenna DE. In some experiments A was connected to earth, in others a wire similar to DE was attached to A, while in one series this end of the doublet was left entirely free

The knobs B, C were not kept polished, and the spark was about $1{\cdot}9^{mm}$ long.

For earth, in the case of wires of lengths 500, 1500 and 2000^{cms}, A was joined immediately to a large sheet of tin, which, along with about two square meters more of sheet metal, was firmly connected to a steam-heating radiator near by. For the wire 1000^{cms} in length the connection from A to the sheet of tin was about 75^{cms} long.

The wire joined to A in place of the earth connection was precisely the same as that acting as antenna and attached to D; and in order to prevent inductive effects between these two wires the former was drawn up in a vertical direction by a cord over a pulley in the ceiling.

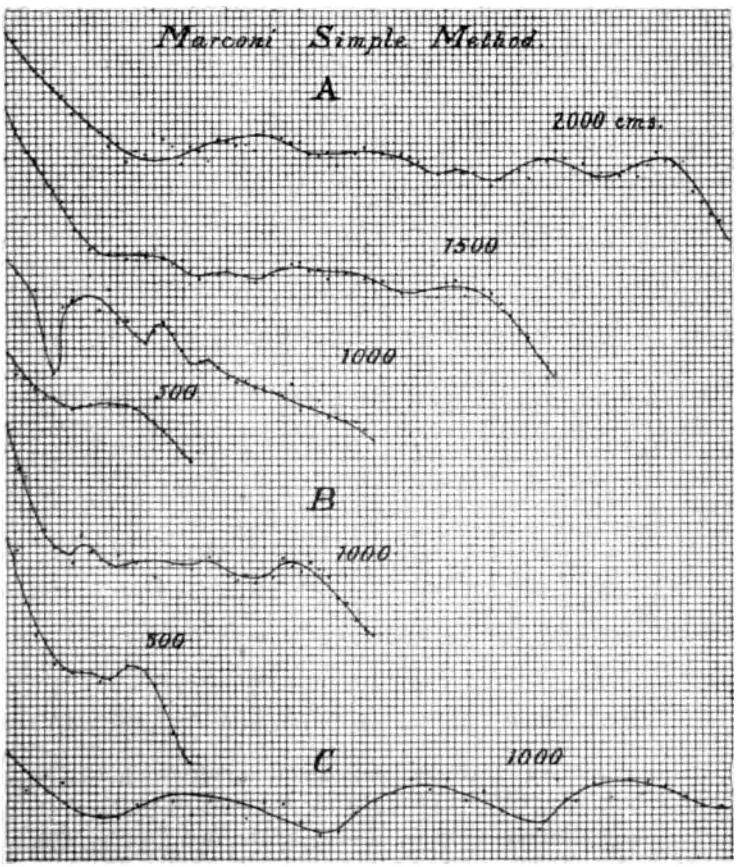
The readings were taken at points, usually 20^{cms} apart, from one end of the antenna to the other, the order of the readings in some cases beginning at the free end, in the rest moving towards it.

A general view of the results obtained is given in Table I and fig. 3. In the table the distances of the minima from the free end are given in centimeters, and the less-marked minima are enclosed in brackets.

TABLE I.

Length of antenna. cms.	Distance, in centimeters, of minima from free end of antenna. A With earth connection.	B With equal long wire.	C No earth connection.
500	(175). None	260. None	--------
1000	(120), (375), (500). None	(150), (660). None	130, 425, 715, (1000 ?)
1500	(320 ?). None	--------	--------
2000	None	--------	--------

3



In all the curves abscissas represent distances from the free end and ordinates magnetometer deflections.

It is seen from the curves, that joining to earth one pole of the oscillator is equivalent to adding to that pole a wire similar to the antenna; or, in other words, the earth acts like a plane mirror in optics. This view has been put forward by several writers, especially by Slaby* when offering an explanation of his system of syntonic telegraphy.

In the curve obtained with the antenna of 1000^{cms} connected to earth (see fig. 3), there is a deep minimum at approximately 123^{cms} from the free end, and a second one at 375^{cms}. This would give

$$\begin{aligned} \lambda/2 &= \phantom{375-{}}2\times 123 = 246^{cms} \\ &= 375-123 = 252^{cms} \\ &\text{Mean} \qquad \overline{249^{cms}} \end{aligned}$$

In the curve obtained with no earth or other connection the natural oscillation of the wire as a whole is practically absent, but there are minima at distances

$$130,\ 425,\ 725,\ (1000\,?)^{cms}$$

That at 1000^{cms} is not decisive from the curve, and so it is omitted in the following calculation (though including it would make no difference in the result):

$$\begin{aligned} \lambda/2 &= \phantom{425-{}}2\times 130 = 260^{cms} \\ &= 425-130 = 295^{cms} \\ &= 715-425 = 290^{cms} \\ &\text{Mean} \qquad \overline{282^{cms}} \end{aligned}$$

These, I believe, are half-wave-lengths of overtones. In the first case the wire was grounded and so only odd overtones would be possible, the one present being probably the ninth, counting the fundamental, the first. If such was the case, the entire length of the oscillating wire from free end to earth should be

$$9\times\frac{249}{2} = 1120^{cms},$$

a result requiring the oscillator to be equivalent to

$$1120-(1000+75), \text{ or } 145^{cms}$$

of the wire. This value appears rather high, but this explanation seems to me the most probable.

I may remark that the curves obtained with the wire 1000^{cms} long, connected to the earth, were the most irregular of

* A. Slaby, Funkentelegraphie, 2d ed., p. 86, and fol. Berlin, 1901.

all secured during the investigation, especially in the space between 100 and 300^{cms} from the free end. A possible cause contributing to this may have been that the electrical disturbance was not produced immediately at the earth end.

In the second case the oscillating wire was free at each end, and so the entire system of overtones was possible. The one present, with half-wave-length of 282^{cms}, seems to be the fourth, in this case the oscillator adding to the wire one-fourth of a wave-length.

It may be questioned why these particular overtones were present, and the others not noticeable. I think it was because the natural period of the oscillator alone was in approximate accord with them, being about one-half that of those exhibited. This would agree with the results of Lindemann,* who found that the waves proper to the oscillator, as well as those of the entire system of oscillator and wires, should be present.

I have not been able to identify the other ripples of the curves.

Slaby† and Braun‡ have both studied the simple Marconi system. The former used a wire about 10 meters long, and explored it with a spark micrometer in which a blunt metal cone was opposed to a flat face of arc carbon. According to the curve he obtained (fig. 1 of his article), there was a standing wave, with potential loops at the ends and a relative node in the middle. In my experiments there is a node at the end of the wire attached to the coil. Slaby concluded that the overtones present were very trifling and that the oscillation emitted was almost a pure fundamental. The fundamental is certainly present in great intensity, but the readings giving it are sometimes scattering, as mentioned above, and the curve is not very smooth. In some cases, too, as already seen, overtones show in considerable strength. Slaby also found that when the pole of the induction coil was joined, not to an end of the antenna but to some other point, the oscillation produced showed considerable distortion. This effect is similar to that noted above in the case of the 1000^{cms} earthed wire.

Braun used a wire 15 meters long stretched horizontally, and from it suspended five small Geissler tubes, each with a wire 50^{cms} long hanging below it. When the coil was in action the tubes lighted up, but there was no trace of a node or a ventral segment.

* A. Lindemann, Ann. der Physik, ii, p. 376, 1900.

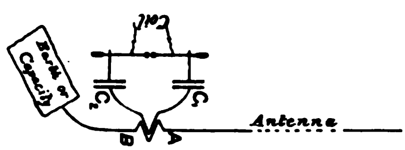
† A. Slaby, Elektrotechnische Zeitschrift, 1902, p. 168; extended abstract in Lond. Electrician, vol. xlix, p. 6, 1902.

‡ F. Braun, Phys. Zeitschrift, iii, p. 143, 1900.

Inductive Method of Excitation (*Braun, Marconi*).

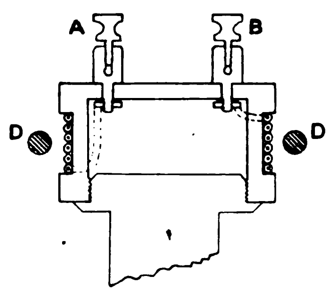
The experimental disposition used for inductively exciting the oscillations about the antenna is illustrated in fig. 4.

4



C_1, C_2 are two condensers. From the inner coatings conductors lead off and end in knobs, between which sparks are made to pass by an induction coil. The outer coatings are joined by a thick wire bent into a single turn which acts as the primary of a transformer. The secondary of this transformer, AB, consists of a few turns. To one end of it, A, the antenna is joined and to the other end, B, the earth, any desired capacity or a wire similar to the antenna.

5



The apparatus actually used in the investigation was the transmitter of the experimental set supplied by the Gesellschaft für drahtlose Telegraphie, Berlin, Germany, of the system Prof. Braun and Siemens & Halske. Each condenser consisted of four small tubular jars, $17{\cdot}5^{mm}$ in diam., 2^{mm} thick and with coatings approximately $7{\cdot}5^{cms}$ high. The spark-gap was from 1 to 2^{mm} long, and no attention was paid to polishing the knobs. That portion of the condenser circuit forming the primary of the transformer was a single turn of copper wire 6^{mm} in diameter, bent into a circle of mean diameter $6{\cdot}8^{cms}$ (D, D, fig. 5). The secondary, which was within the primary, consisted of $5\frac{1}{2}$ turns of heavily insulated wire of a total length of 99^{cms}. The diameter of the wire and its insulation was $2{\cdot}5^{mm}$, and the turns lay close together. A vertical section, one-half of full size, is shown in fig. 5.

As is known, in this system earth connection is usually not made,* but in place of it an earth plate is used, intended to balance the antenna and thus give symmetry to the oscillating system. The earth plate supplied with the apparatus was a hollow metal cylinder, 20^{cms} long and 8^{cms} in diameter. It was joined to a binding post, B, of the transformer secondary by a wire 40^{cms} long. When it was desired to join B to earth the cylinder was securely bound to a large metal plate, which, along with other metal sheets, was connected to the heating-radiator. When employing a wire similar to the antenna to balance it, this wire was joined to B and, as in the experiments described above, was drawn up towards the ceiling.

In supplying the apparatus the makers stated that it was designed to emit waves of length 10 meters. It was very constant in its action and easy to handle.

An extended series of observations was made with antennæ varying from 200 to 1000^{cms}, and with four different attachments to the end B of the transmitter transformer, as follows:

A. With cylinder joined by a wire 40^{cms} long.
B. With earth joined to this cylinder.
C. With a wire similar to the antenna joined to B.
D. With the end B free.

A view of the results obtained is given in Table II, and figs. 6, 7, 8, 9.

TABLE II.

Inductive Method.

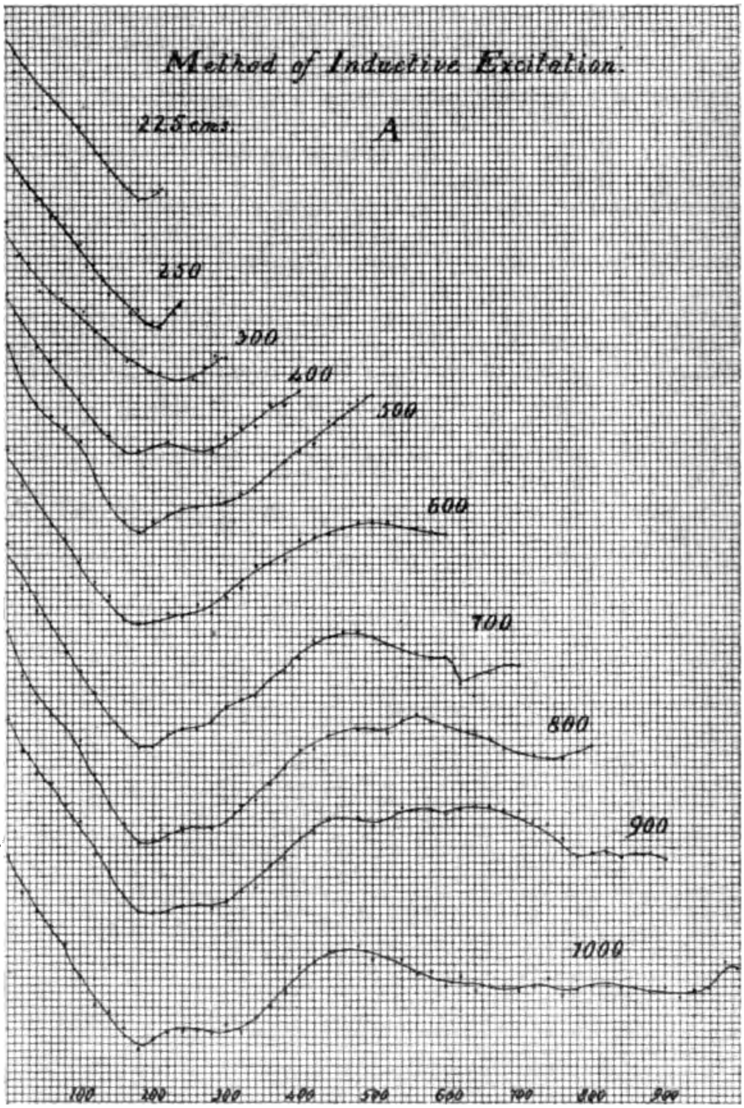
Length of antenna. cms.	Distance, in cms., of minima from free end of wire.			
	A. With cylinder capacity.	B. With earth connection.	C. With equal wire.	D. With end free.
200	....	....	....	140
225	184	190	(70), (190). None	....
250	200	180	(90). None	....
300	[238]	187	[225]	148
400	187, (265)	185	185	160, (280?)
500	180	180	180	183
600	186, (375), (520)	200, (520)	182	167, (415)
700	188, (637)	200	180	148, 617
800	191, (745)	200	189	....
900	200, (790)	200, (380), (790)	193, (790)	....
1000	180, (320)	208, (800), (920)	180, (860)	....
Mean	188·4	193	184·1	
	Mean of 184·4, 193, 184·1 = 188·5^{cms}.			

On examination it will be seen that the curves obtained by the three methods, A, B, C, are hardly distinguishable from

*** See discussion on a paper by M. Wien, read before the 74. Versammlung deutscher Naturforscher und Aerzte at Carlsbad, Sept., 1902.—Phys. Zeit., Oct., 1902.**

each other. Those with method D differ from these somewhat.

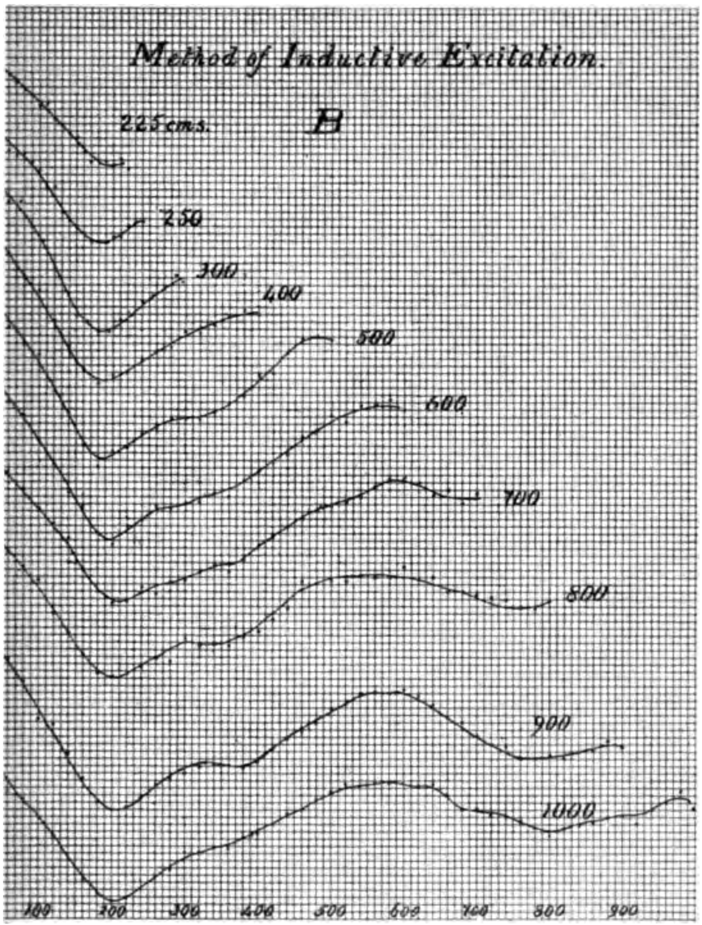
6



In A, B, C, there is a gradual fall from the free end to the other, which gives the fundamental of the wire itself; but

rposed on this and more prominent than it, is another lation very definitely formed as far as the first minimum. is unquestionably due to the oscillation of the condenser

7



uit, and the distance from the free end to the minimum is arter-wave-length of it.

With wires of lengths 225 and 250cms in disposition C, e is to be seen only the fundamental of the wire, while length 300cms in dispositions A and C the minimum ears abnormally displaced. The curves in these last two

cases are not so smoothly formed and are not considered in the calculation of the means given in Table II. The mean of the

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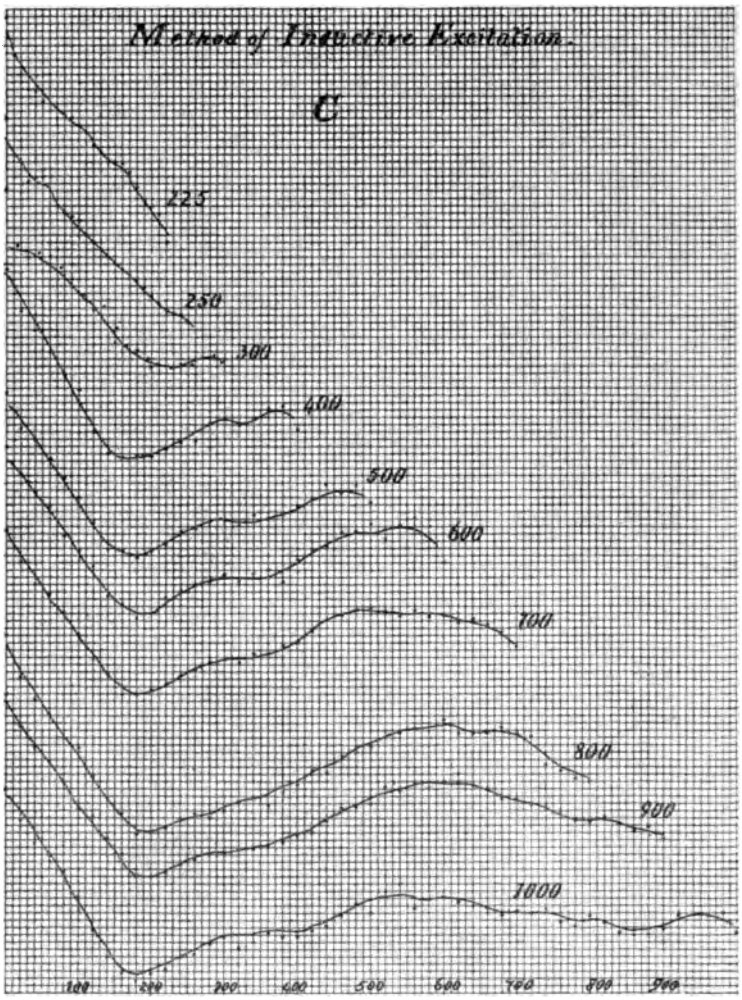
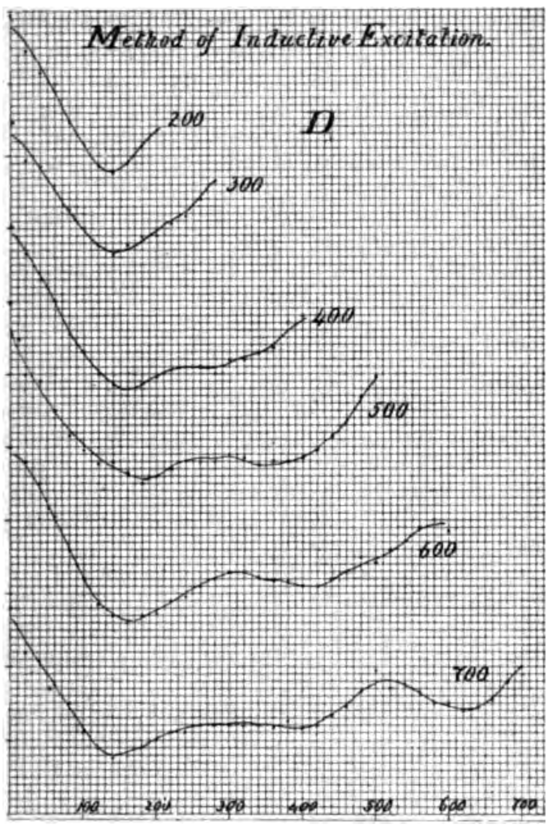


three means given in the Table is 188·5^{cms}, which I take to be quarter-wave-length of the condenser circuit oscillation.

The curves obtained with disposition D, shown in fig. 9, differ somewhat from the others. Here the variation of potential at the end joined to the transformer is almost as great as

that at the free end. This is due, without doubt, to the fact that the antenna and transformer secondary together compose a single conductor, and the fundamental oscillation would have a potential loop at each end. But the chief minimum shows a rather remarkable variation. As the length of the antenna

9



is increased the distance of the minimum from the free end increases until it reaches its greatest value with a wire 500^{cms} long, and then it decreases. The reason for this is not very evident, but it seems that in this disposition the reaction of the secondary of the transformer upon the primary varies with the length of the antenna joined to it, thus altering its frequency, the greatest change being when the wire is 500^{cms} long. With antenna of this length the readings were the highest of the

series, and the quarter-wave-length deduced from the curve approximately the same as that obtained in the dispositions A, B, C.

As has been already remarked, the curves are very clearly defined. The successive sets of readings agree remarkably well, but yet it was impossible to get a second mimimum at a distance of three-quarters of a wave-length from the end.. This is not what was looked for with this transmitter. One would expect the condenser circuit, with its persistent oscillations, to keep up perfect standing waves in a wire in resonance with it, but with no length used was this satisfactorily exhibited.

The waves radiated from the wire, no matter what its length, have the frequency of the condenser circuit, and also, to a smaller degree, that of the fundamental of the wire. Overtones are scarcely noticeable.

From my experiments it must be concluded that the earth connection does not injuriously affect the *form* of the oscillation about the antenna; indeed, the curves obtained with disposition B are rather more uniform than those with the others. The earth connection, however, assuredly has influence in other ways. I believe all systems of wireless telegraphy except the Braun and the Lodge-Muirhead* join both transmitter and receiver to earth; and, according to Jackson,† severing the earth connection reduced the signalling distance by 85 per cent. The action of the earth must be that of *guiding* the waves, thus allowing them to pass over obstacles such as the bulging-out of the earth's surface. The explanation given by Taylor‡ seems the most satisfactory.

This explanation is very similar to that suggested by Lecher,§ and to that by Heaviside.‖ More recently Köpsel¶ has put forward the view that in Marconi's long-distance transmission the earthing wire and earth capacity form a system in partial if not in entire resonance with the antenna. There may have been some such effect in the transatlantic experiments, but such can hardly be the case in the numerous experiments by other workers who find ground connection necessary to success.

* See Nature, vol. lxviii, p. 247, July 16, 1903; N. Y. Electrical World and Engineer, vol. xlii, p. 173, Aug. 1903.

† H. B. Jackson, Proc. R. S., lxx, p. 254, 1902.

‡ J. E. Taylor, Lond. Electrical Review, May, 1899. See also L. de Forest, N. Y. Electrical World and Engineer, May 17, 1902; Prasch, Die drahtlose Telegraphie (Stuttgart, 1900), p. 65.

(See, however, a communication on Theories in Wireless Telegraphy in N. Y. El. W. & E., Oct. 31, 1903, by R. A. Fessenden.—Note added on correcting proof.)

§ E. Lecher, Phys. Zeitschrift, iii, p. 13, 1902; iv, p. 320, 1903.

‖ Heaviside, Electromagnetic Theory, i, § 60; ii, § 393. See preface to vol. ii.

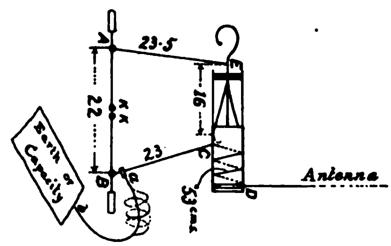
¶ A. Köpsel, Dingler's Polytechnisches Journal, June, 1903; abstracted in N. Y. Electrical World and Engineer, Aug. 29, 1903.

Method of Direct Excitation (*Slaby-Arco*).

In the method of *directly exciting* the oscillations, one point of the condenser circuit is joined to the antenna, another point to earth.

A diagram of the connections is shown in fig. 10.* A and B are the terminal binding posts of the secondary of the induc-

10



tion coil, the distance between them being 22^{cms}. The spark-knobs, K, K were $16{\cdot}5^{mm}$ in diameter and the spark-length was from 1 to 2^{mm}. The Leyden jar had a mean diameter of $5{\cdot}7^{cms}$, with walls about 4^{mm} thick. The coatings were 10^{cms} in height and of area about $180^{sq\ cms}$. The lengths of the various parts of the circuit are indicated on the figure, the entire condenser circuit having a length of approximately

$$53 + 23 + 22 + 23{\cdot}5 + 16 = 137{\cdot}5^{cms}.$$

The wire CD wrapped about the jar was heavily insulated and consisted of $2\frac{1}{2}$ turns. This corresponds to Slaby's "syntonizing coil," though, of course, it was not used for syntonization in my experiments. The turns were about 2^{cms} apart, so that its self-induction was practically the same as that of an equal length of straight wire. It was put in this form, however, through a desire to have the arrangement as nearly as possible like that used in actual practice.†

It will be seen that 75^{cms} of the closed condenser circuit are a part of the open antenna circuit. According to Braun,‡ the larger this portion of the condenser included in the antenna is, the better will be the effect, and it performs a rôle other than simply as a portion of the antenna.

Four different arrangements were employed to balance the antenna wire.

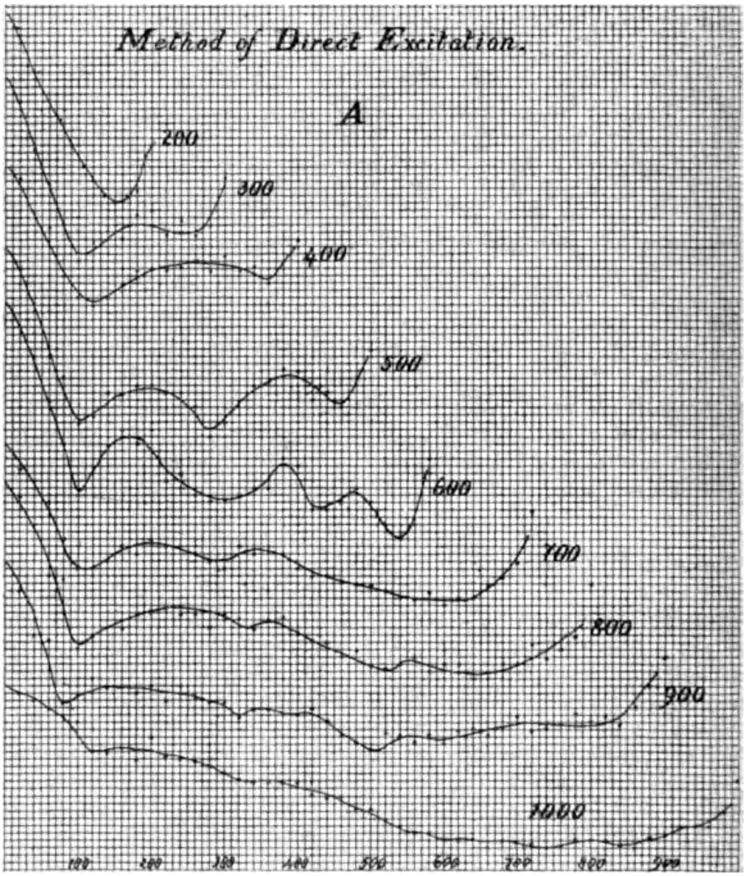
* The arrangement was taken from that described by the Allgemeine Elektricitäts Gesellschaft in their circular regarding the Slaby-Arco system, 1902. See also Boulanger et Ferrié, Télégraphie sans Fil, p. 156, 4th ed., 1902.

† Several good illustrations of the latest apparatus are given in C. Arldt, Die Funkentelegraphie, pages 48–51 (Leipzig, 1903).

‡ F. Braun, Ann. der Physik., viii, p. 199, 1902.

A. The cylinder capacity used in the experiments with the Braun transmitter was connected to the condenser circuit at *a*, the length of the wire *ab* being 40^{cms}. Thus the length from this capacity to the end D, of the antenna, was $40+75 = 115^{cms}$.

11

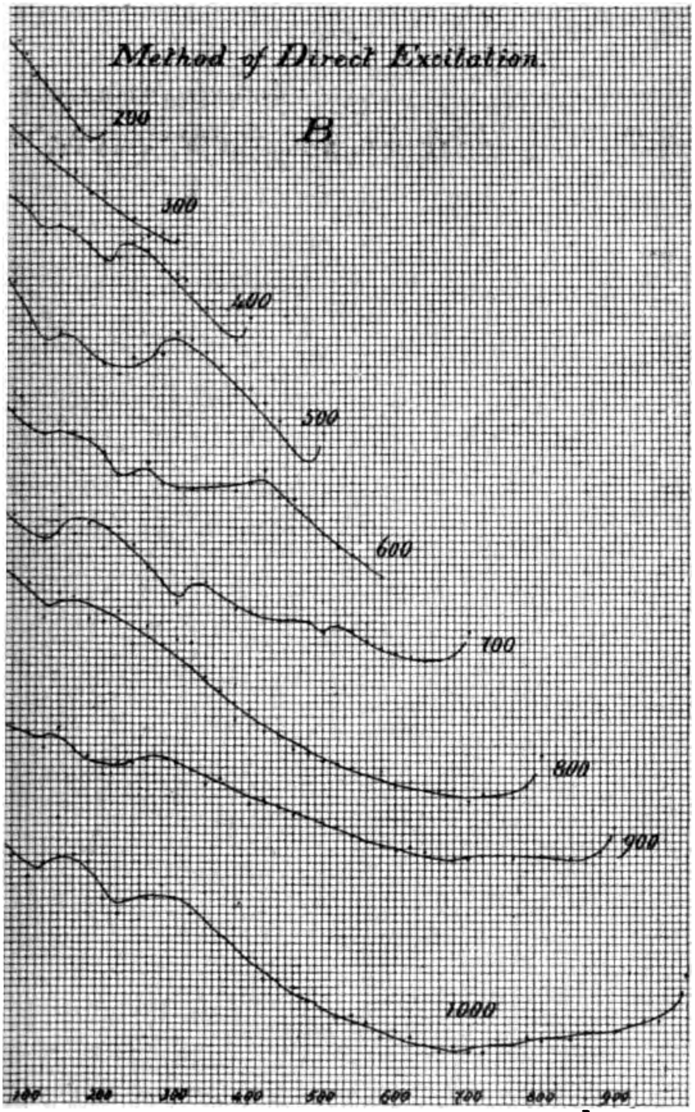


B. The point *a* was joined to earth (the same as above), the wire *ab* being 25^{cms} long. In this case the length of the conductor between earth and D was $75+25 = 100^{cms}$.

C. To *a* was attached a wire precisely similar to that used as antenna. Here the two wires were joined by 75^{cms} of the condenser circuit. As before, the balancing wire was drawn up in a vertical direction towards the ceiling.

The same as B, except that between *a* and *b* an induct-coil was inserted. This coil was of heavily-insulated

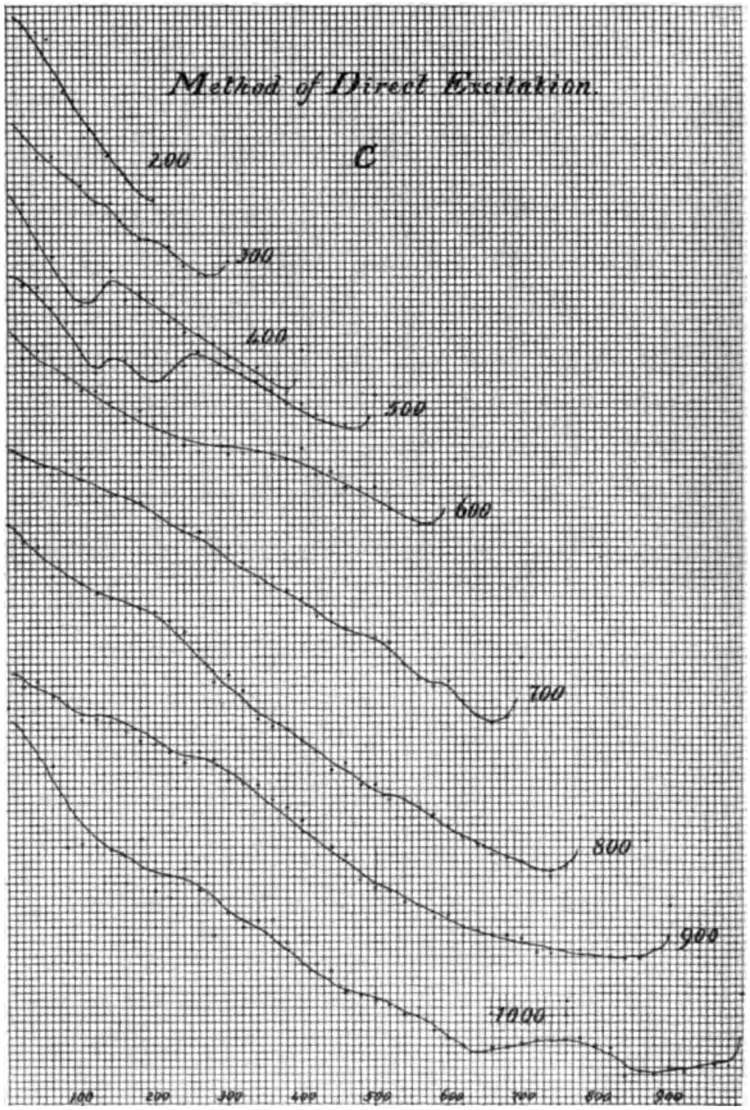
12



the conductor having a diameter of 2^{mm}, the diameter all being 7^{mm}. There were 4 turns lying close together,

with a total length of 82^{cms}. The object was, of course, to see if there would be any evidence obtained of the wave length

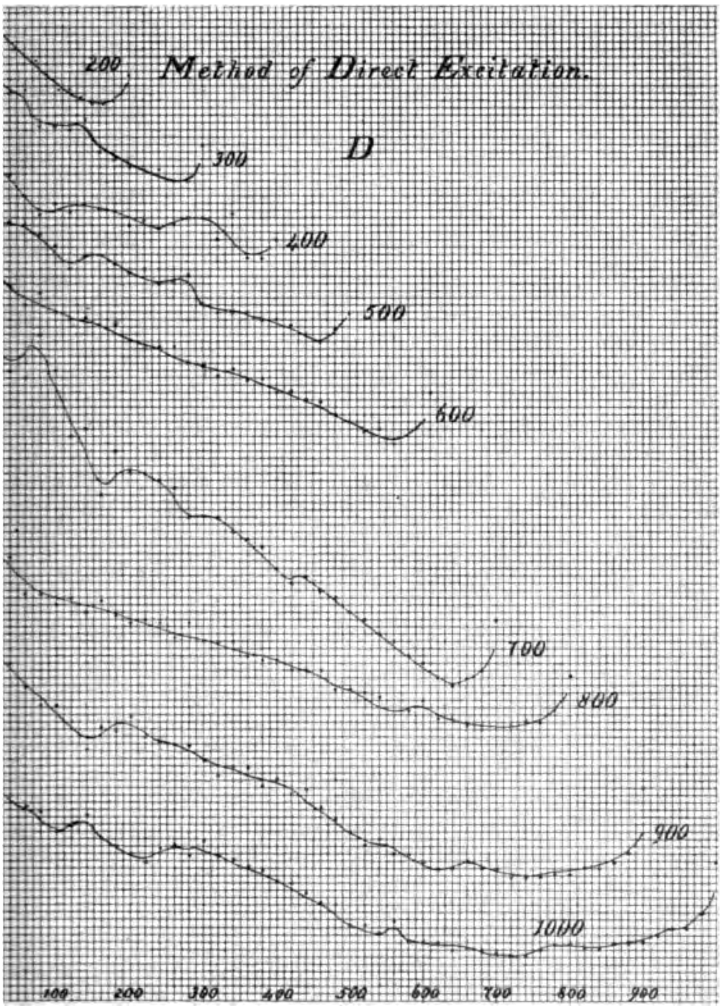
13



being increased by inserting this inductance coil at the base of the antenna. In this case the length of the conductor from D to earth was $75+82+25 = 182^{cms}$, though the inductance coil, itself, would probably be equivalent to 200^{cms} of straight wire.

A view of the results obtained on using wires varying in ıgth from 200 to 1000^{cms} and the four experimental disposi- ·ns just described is given in Table III and the curves of s. 11, 12, 13, 14.

14



It is seen that the curves obtained with disposition A (fig.) are of a different type from those with the three other ›positions. In these latter there is always a gradual but cided drop of potential-variation from the free end of the re, that is, the fundamental of the wire is very intense,

TABLE III.

Method of Direct Excitation.

Length of antenna. cms.	Distance, in cms., of minima from free end of wire.			
	A. With cylinder capacity.	B. With earth connection.	C. With equal wire.	D. Inductance spool and earth.
200	(60), 153	None	None	(60), 160
300	100	None	None	(90). None
400	120, 360	(120), (205). None	105. None	80, 230, 380
500	106, 280, 455	(120), 215	(125), 198	(120), (200), (320)
600	100, 290, (435), (545)	None	None	None
700	110, 300, (580)	100, 300, 500. None	(120). None	(58), (170), (280), (420). None
800	100, (300), (518), (650)	(120). None	None	None
900	90, 310, 495	(200). None	None	(140), (320), (740). None
1000	(160). None	(100), (220), (700 ?)	(100). None	(100), (220). None

though the curves show other oscillations superposed. With disposition A this strong fundamental is absent, and the minima present are undoubtedly due to the oscillations impressed on the wire by the condenser circuit. All through this series will be seen a minimum occurring at approximately 100^{cms} from the free end of the wire, and in many cases one or two other minima spaced at approximately 200^{cms} apart. The same minima appear in disposition B with wire 700^{cms} long, and C with wire 400^{cms}.

The mean value of the wave-length is 404^{cms}, calculated as follows:

	Wire		$\frac{\lambda}{2}$
A.	300	$2 \times 100 =$	200^{cms}
	400	$2 \times 120 =$	240^{cms}
		$360 - 120 =$	240^{cms}
	500	$2 \times 106 =$	212^{cms}
		$280 - 106 =$	174^{cms}
		$455 - 280 =$	175^{cms}
	600	$2 \times 100 =$	200^{cms}
		$290 - 100 =$	190^{cms}
	700	$2 \times 110 =$	220^{cms}
		$300 - 110 =$	190^{cms}
	800	$2 \times 100 =$	200^{cms}
	900	$2 \times 90 =$	180^{cms}
		$310 - 90 =$	220^{cms}
		$495 - 310 =$	185^{cms}
B.	700	$2 \times 100 =$	200^{cms}
		$300 - 100 =$	200^{cms}
		$500 - 300 =$	200^{cms}
C.	400	$2 \times 105 =$	210^{cms}
		Mean	202^{cms}

The curves in B and C (figs. 11, 12) are very similar, from 'hich it is to be concluded that the simple earth connection is quivalent to a wire similar to the antenna, or, as already indi- ated in previous experiments, the earth acts as a mirror.

The curves in D (fig. 14) are not so regular in their form as 1ose in B and C. There is a gradual fall of potential, but 1e fundamental is not so intense as in the others, and there is superposition of other oscillations. This agrees with the :atement of de Forest* that with this arrangement there is ability to overtones. It is to be observed, too, that here gain the disturbance is produced at some distance from the arth end.

It is to be noted that none of the curves in A is similar to ny in C. From this it follows that though as far as the *fre- uency* of the oscillations in an open circuit is concerned, a apacity may replace an inductance, still the *form* of the oscil- 1tions is quite different in the two cases.

Thus the direct method is in general result similar to the imple system, but it is more regular and more powerful. ɩccording to Wien† the radiation is 13 times as intense as that f the simple radiator.

III. *Conclusions.*

The following conclusions seem to follow from my experi- 1ents:

1. In the simple Marconi method and the method of direct xcitation, when the antenna is joined to earth, the effect is imilar to using a wire the same as the antenna to balance it; hat is, considered from an optical point of view, the earth cts as a plane mirror.

2. In these conditions the chief oscillation is the funda- nental of the antenna, with wave-length four times its length. The condenser circuit in the method of direct excitation mpresses its wave-length on the antenna, but its oscillations re not nearly so intense as those proper to the antenna itself. Thus the manner of oscillation is essentially the same in the wo methods, but the latter is more regular and powerful than he former.

3. In the inductive method of excitation, on the other hand, he prominent feature of the oscillations is that one due to the ondenser circuit. With antennæ of different lengths there is ittle change in this oscillation, the curve indicating it being lecided and definite; but only one quarter of its wave-length s shown. This may be due to the great losses from radiation y the wire. The fundamental proper to the antenna is also

* L. de Forest, N. Y. Electrical World and Engineer, May 17, 1902.

† M. Wien, Ann. der Physik, viii, p. 686, 1902.

present, but it is not nearly so intense as in either of the other two systems.

4. The most effective length of the antenna, therefore, is *one* quarter-wave-length, not a higher multiple.

5. When inductance is inserted between the condenser circuit and the earth the fundamental oscillation is not so regular or intense, other oscillations (overtones) being superposed.

6. For the production of oscillations by the direct method a small capacity cannot satisfactorily balance the antenna; in the inductive method, however, a capacity acts like an earth connection or a similar wire.

IV. *Continuation of Former Investigation.*

In the previous experiments with Hertzian plate oscillators of various sizes and with wires ranging in length from 300 to 860^{cms}, there was usually one "chief" minimum of potential-variation between 100 and 200^{cms} from the free end, and always a marked one about 10 or 15^{cms} from the other end of the wire. It was hoped that by employing longer wires the phenomena of standing waves would be much better exhibited, and that several "chief" minima would be shown. Such, however, has not proved to be the case. Wires 2050 and 4090^{cms} long were carefully explored, the action on the wire being produced by means of an oscillator having plates 40^{cms} square and the straight connection between 60^{cms} long, but the only unmistakable minimum was approximately 150^{cms} from the free end, the same as was perfectly formed with wires from 300^{cms} upwards.

Some evidence was obtained as to the cause of the marked minimum near the other end of the wire. It is due to the direct action of the oscillator on the detector. As described in the other paper, an attempt had been made to allow for this direct action by taking the reading when the wire was in place and also when it was removed, and then subtracting the latter from the former. This assumes that the two effects are quite independent, but such seems hardly to be the case. In the former experiments the detector lay in a horizontal plane on the top of a carriage which was moved along the wire. Thus the detector's length was parallel to that of the oscillator, though the little *wing* was perpendicular to it. As described in Part II of the present paper, the detector was now hung in a vertical plane from the wire, so that its length was perpendicular to the axis of the oscillator. With this arrangement the minimum disappeared, thus showing that it had been produced by the direct action of the oscillator on the detector.

University of Toronto, Toronto, Canada.

ART. II.—*Studies of Eocene Mammalia in the Marsh Collection, Peabody Museum;* by J. L. WORTMAN.

[Continued from vol. xvi, p. 368.]

SUBORDER ANTHROPOIDEA.

IN a previous part of the present work, I have given the ıaracters by which this suborder is distinguished from the heiromyoidea and the Lemuroidea. I have likewise proposed ıd defined three divisions of the Anthropoidea, of which *Tarus* and its allies constitute the first (Paleopithecini), the livg marmosets the second (Arctopithecini), and the remaining gher Primates the third (Neopithecini). Of the twelve or ore species of the Anthropoidea now known to occur in the ridger, the organization of at least three can be determined ith some degree of satisfaction from the material now at hand. his information is not limited to any one part, but includes ɜarly every portion of the skeletal structure. It is reasonably ear, therefore, that these three species are primitive members : the Neopithecine division of the Anthropoidea. In like anner, the skull of the Wasatch species—the so-called *Anapmorphus homunculus*—is sufficiently complete and well prerved to show that it is a very near relative of the living East ıdian *Tarsius*, and hence a member of the Paleopithecini. he remaining nine or more species from the Bridger are ɹpresented mostly by teeth alone, and it is therefore not an ısy matter to decide correctly to which of the three groups ıese forms belong.

As regards the Arctopithecini, or the living marmosets, our nowledge is confined almost exclusively to the existing species. ; has been already noted that some of their characters are nique among the Primates. Whether the lack of opposaility of the pollex and hallux is to be looked upon as a degenation from a former more perfect condition of prehensility : the extremities, or whether it represents a stage in the rocess of acquirement of the opposability of these digits, can ot now be determined. It is worthy of note, however, that ıe internal cuneiform and the proximal end of the articuting metapodial resemble the corresponding parts of the ımurs and monkeys much more than those of any other aniıal; and, notwithstanding the lack of opposability, this likeɜss would be sufficiently close to indicate their ordinal position id we know the marmosets from their skeletons alone. There e at the same time some peculiarities in the make-up of these ɔnes, which would lead the cautious anatomist to hesitate in ronouncing upon the opposability of the hallux, especially if

he were to take into consideration the clawed condition of all the digits. The habits of the marmosets, while as strictly and completely arboreal as in any of the Primates, resemble those of the squirrels more than those of the monkeys proper. According to Bates, who had excellent opportunities for observing them in their native forests, the Negro Tamarin (*Midas ursulus*) confines itself mostly to the larger branches, and is frequently seen passing up the perpendicular trunks, clinging to the bark with its claws in a manner not dissimilar to that of the squirrels. This method of climbing is doubtless true of all the marmosets, and the lack of opposability of the hallux and pollex is correlated with the possession of sharp compressed claws instead of flattened nails.

The tritubercular upper molars furnish another character of considerable importance in determining the relationship of the marmosets to the other groups. No Primate of the Eocene is known to possess fully quadritubercular molars. Some of the Adapidæ have a rudimental fourth cusp, but the crown can not be said to be as fully quadritubercular as that of the higher modern apes. By far the greater number of the species have simple tritubercular upper molars, and with the exception of the marmosets and *Tarsius* all the modern representatives of the Anthropoidea have four fully developed cusps. It follows, therefore, that these two groups are survivals from this early condition of the tritubercular stage of development of the molars, and that their detachment from the main axis could not have taken place later than the Eocene. The loss of the last molar in the marmosets, while unusual for a Primate, has clearly taken place since that time, as in the Eocene all the known species have three fully developed molars. There is still another feature of importance exhibited by certain of the marmosets, which is worthy of notice. Forsyth Major found that, out of nineteen skulls of *Hapale* examined, in six the lachrymal extends beyond the orbit to such an extent as to join the nasal and exclude contact between the maxillary and frontal.* This is also true of two skulls of this genus in the Peabody Museum, and I am satisfied that this more primitive condition of the lachrymal is by no means of infrequent occurrence among these species of marmosets. These features are associated with a characteristic lack of depth of the lower jaw, a subglobular form of the condyles, and small size of the lower canines, which do not exceed the incisors, all of which constitute so many steps in the approximation to certain of the Paleopithecine apes of the Eocene. Upon the whole, I am fully persuaded that the ancestors of the marmosets must be sought for among the members of this latter group, and that

* Proc. Zool. Soc. London, Feb. 19, 1901, p. 146.

they had not departed very widely from the parent stock at the close of the Eocene. One of the earliest recognizable characters in the dentition by which they can be distinguished will undoubtedly be found in the reduction in the last molar. It is doubtful, moreover, whether in the history of this phylum the hallux and pollex have ever been opposable.

SECTION PALEOPITHECINI.

Tarsius spectrum is the only living member of this group, and on this account its skeletal organization has an unusual interest for the paleontologist. In many particulars it still retains the generalized features which characterized its Eocene ancestors, while in others it has added some structural modifications, due doubtless to adaptation to slightly different modes of life. These characters relate to the loss of one pair of lower incisors, the development of a bony partition between the orbital and temporal fossæ, the reduction of the fibula and its coössification with the tibia, the grooving and broadening of the astragalus, and lastly the great elongation of the calcaneum and navicular. These modifications of the hind limbs are evidently in relation with, and the result of, saltatory habits, since *Tarsius* in common with all the lemurs having elongate tarsals is a powerful leaper.

The arboreal habits of the Primates have prevented in large measure the development of any great cursorial powers on the part of any of the species, but the habit of leaping from branch to branch has proved of manifest advantage to some of them in the capture of their prey, for in a number of the living species of lemurs this habit is almost as pronounced and highly developed as in certain groups of the Rodentia, the kangaroos, and others. According to Mr. Bartlett, late Superintendent of the London Zoological Gardens, Garnett's Galago is an especially active leaper. In speaking of this species, in a letter to Duncan quoted in Cassell's Natural History, Vol. I, p. 215, he says: "The other night I took an opportunity of letting one of these interesting creatures—Garnett's Galago—have his liberty in my room, and I assure you I was well repaid by his performance. Judge my utter astonishment to see him on the floor, jumping about *upright* like a Kangaroo, only with much greater speed and intelligence. The little one sprung from the ground on to the legs of tables, arms of chairs, and indeed on to any piece of furniture in the room; in fact, he was more like a sprite that the best pantomimist I ever saw. What surprised me most was his entire want of fear of Dogs and Cats. These he boldly met and jumped on at once, and in the most playful manner hugged and tumbled about with them, rolling over

and over, hanging on their tails, licking them on the head and face. I must add, however, that now and again he gave them a sharp bite, and then bounded off, full of fun at the noise they made in consequence of the sly nip he had inflicted. This active trickery he never appeared to tire of; and I was myself so pleased on witnessing the droll antics of the creature that the night passed and it was near daybreak before I put a stop to his frolics by catching and consigning him to his cage. In bounding about on the level ground, his jumps, on the hind-legs only, are very astonishing, at least several feet at a spring, and with a rapidity that requires the utmost attention to follow. From the back of a chair he sprang, with the greatest ease, on to the table, four feet distance."

The other species of *Galago*, as well as those of the Madagascar *Cheirogaleus*, also exhibit much activity, and have the power of leaping great distances in proportion to their generally diminutive size. Duncan says of the Senegal Galago (*Galago senegalensis*):* "It pursues Beetles, Sphinges, and Moths with great ardour, even while they are on the wing, making prodigious bounds at them, and often leaping right upwards to seize them. Should it by chance miss its object and accidentally fall from the branch to the ground, it re-ascends with the rapidity of flight to renew the hunt."

Tarsius is also a powerful leaper for so small an animal, and although not larger than a small common squirrel is said to make prodigious springs, both in the branches of the trees and on the ground, in pursuit of its prey.

Among many other groups of Mammalia, the leaping habit is by no means uncommon, and as a result important structural changes in the limbs are to be met with. In all such cases, however, if any modification of the hind limbs takes place in response to this mode of progression, it is almost without exception the metatarsus alone that is affected. Thus, among those forms of Rodentia in which the saltatory habit is most highly developed, as the Jerboas, the Cape Jumping Hare, and others, the metatarsals are greatly elongated and modified. The same is true of the characteristic leapers among the marsupials, as exemplified by the kangaroos and their allies. The development of this habit in certain of the Primates, however, has affected, not the metatarsals, but the tarsals, and the elongation is found in the calcaneum and navicular. This arrangement is unique among the Mammalia, and occurs in no other group of the Vertebrata except the Batrachia, notably the tree-frogs, as was long ago pointed out by Huxley.†

The cause for this modification of the tarsal bones to the

* Loc. cit., p. 238.

† The Anatomy of Vertebrated Animals, 1872, p. 389.

exclusion of the metatarsals is not certain, but it is in all probability in some way associated with the retention of the opposable hallux in the development of the elongated pes. It is of interest to note just here that the fourth digit of all those Primates with elongated tarsals is very perceptibly the longest and strongest of the series, more so, in fact, than in those species in which the tarsals are not elongated. It is all but certain that if this modification were to continue in an exclusively terrestrial habitat long enough to cause the opposable hallux to disappear, the fourth digit would become enlarged and modified, as in the kangaroos and their allies. The chief differences would, of course, be in the elements elongated. The shifting of the axis to the outside and the specialization of the fourth digit are the strongest possible proof that the foot of the kangaroo has been derived from an ancestral type in which the hallux was fully opposable, and hence indicating an arboreal habitat for its possessor. *Tarsius* is the most highly modified of all the Primates with respect to the elongation of the tarsals, as is shown by the reduction in size and the coössification of the fibula with the tibia, as well as in the grooving and broadening of the astragalus. It is in this species that the preponderance in the length and strength of the fourth digit over its fellows is greatest.

Of the known representatives of Eocene Primates in North America, there are no less than six or seven genera, including at least twelve species, which are more or less closely related to *Tarsius.* The skull is known in two of these species only, the remainder being represented by teeth and jaws exclusively. On account of the incompleteness of many of these remains it is quite impossible to determine whether they are members of the Paleopithecini or Neopithecini. It will require a knowledge of the relations of the lachrymal, as well as of the structure of the limbs, before these points can be finally determined. That they do not belong in the Lemuroidea is shown by the characters of the lower incisors and canines, which are known in all the species with the exception of one or two. As a mere matter of convenience in grouping, I arrange a number of these species temporarily in the Paleopithecini. In so doing, however, I wish to state distinctly that there are very good reasons for regarding some of them, at least, as true monkeys, directly ancestral to certain of the living South American forms. This will be further discussed under the descriptions of the species.

The divisions of these species of Primates into family and subfamily groups is in the present state of our knowledge attended with much difficulty. In one series including the genera *Omomys*, *Hemiacodon*, and probably *Euryacodon* also,

there are nine teeth in the lower jaw, which with little doubt are to be interpreted as two incisors, one canine, three premolars, and three molars. In another series which includes *Anaptomorphus*, *Washakius*, *Necrolemur*, and presumably *Microchœrus*, there are only eight teeth in the lower jaw, as in *Tarsius*. In this latter genus, the missing tooth is known to be an incisor, and it is almost equally certain that in *Anaptomorphus* it is a premolar. In *Necrolemur*, although perfect lower jaws bearing the full inferior dentition are known, it is quite impossible correctly to assign the teeth in the front of the jaw to their proper categories. In the case of *Washakius*, if the total number of teeth is correctly determined to be eight in each lower jaw, then it is reasonably certain that the missing tooth is an incisor, as in *Tarsius*. Just what significance is to be attached to those differences can not now be properly estimated, but if among the living Lemuroidea the presence or absence of one tooth does not indicate more than a subfamily distinction, I fail to see why such a character should be regarded as of greater importance among the extinct forms. It has been customary with some authors to associate *Microchœrus* and *Necrolemur* in a separate family, and remove them from the American species, on account of the complexity and more advanced character of their teeth. It has, in fact, been insisted upon by Leche* that they belong to the Lemuroidea. If, however, the carotid circulation is like that of *Tarsius*, they, with the American forms, probably belong in the Paleopithecini; and the complexity of their teeth will no more entitle them to distinct family rank than that of the Indrisinæ would cause them to be classified as a separate family of the Lemuroidea. The differences in tooth structure between *Necrolemur* and *Hemiacodon* are not as great as they are between *Propithecus* and *Lemur*.† I therefore provisionally arrange these extinct forms in a single family Anaptomorphidæ, with at least two well-marked subfamily divisions. There can be no doubt apparently that *Tarsius*, by reason of the modification of its hind limbs and because of other modernized features, should be placed in a distinct family.

* Untersuchungen ueber das Zahnsystem lebender und fossiler Halbaffen. Festschrift für Carl Gegenbaur, Leipzig, 1896.

† That *Necrolemur* and *Microchœrus* exhibit some striking resemblances to the Indrisinæ among the Lemuroidea, however, is certain, and it may well be that in these forms we have the ancestors of this group of lemurs and a true transition from the more or less upright position of the lower incisors to that of the procumbent implantation.

Family Anaptomorphidæ.

The family is divisible into two subfamilies, as follows:

Nine teeth in the lower jaw.	Omomyinæ.
Eight teeth in the lower jaw.	Anaptomorphinæ.

Subfamily Omomyinæ.

The genera of this subfamily are distinguished by the following characters:

Lower molars having three cusps on trigon, the anterior cusp of the last molar not being as distinct as that of the others; heel of last molar with three cusps; first and second molars narrow in front, with wider heel; last molar slightly smaller than first and second, with heel very little wider than trigon; fourth lower premolar with small internal cusp and an indistinct heel; third lower premolar without internal cusp or heel, but having a pointed crown whose summit rises above the crowns of the other teeth; canine larger than incisors or second premolar; neither first nor second incisor enlarged; superior molars tritubercular, with rounded external angles, and but moderately extended transversely; intermediates faint or absent; a rudimental postero-internal cusp present on first, less distinct on second, and absent on third molar; first and second molars subequal, third slightly smaller. *Omomys.*

Lower molars having three cusps on trigon, the anterior of the third being least distinct; heel of last molar with three cusps; first and second molars narrow in front, with broader heel; last molar longer but narrower than first and second, with heel very little wider than trigon; fourth inferior premolar with strong internal cusp and distinct heel; third premolar with rudimental internal cusp and heel; summit of crown not high and pointed as in *Omomys;* second premolar, canine, and external incisor small and of equal size; first incisor enlarged; superior molars tritubercular, with squarish outline externally, and with intermediates very distinct; a small distinct postero-internal cusp on first and second molars, but absent on third; a strong cingulum continued around inside of crown, and developing an additional cusp at the antero-external angle of the crown. *Hemiacodon.*

Lower molars having three cusps on trigon, the anterior cusp of the last molar being absent; heel of last molar without distinct internal cusp; first and second molars without much disparity in width between trigon and heel; last molar narrow and reduced; premolars, incisors, and canines unknown; superior molars tritubercular, with rounded external angles; intermediates small, but distinct; a postero-internal cusp on crown of second molar; cingulum continued around in front, developing a small cusp internal to the main internal cusp; last molar considerably reduced. *Euryacodon.*

Omomys Carteri Leidy.

Omomys Carteri **Leidy, Proc. Acad. Nat. Sci. Phila., April, 1869, and Extinct Fauna of Dakota and Nebraska, 1869, p. 408, pl. xxix, figs. 13, 14; *Hemiacodon nanus* Marsh, this Journal, August 18, 1872, p. 218; *Palæacodon vagus* Marsh, this Journal, September, 1872, p. 224.**

The type of this genus and species consists of a right mandibular ramus containing the third and fourth premolars and the first and second molars, together with the alveoli of all the remaining teeth of one side of the jaw. The specimen was found by the late Dr. J. Van A. Carter, near Grizzly Buttes, in the Bridger Basin, and is preserved in the collection of the Philadelphia Academy. A comparison of the type of *Hemiacodon nanus* with Leidy's very excellent figure, as well as with Osborn's outline drawing from a photograph of the type of *Omomys Carteri*, renders it perfectly clear that the two are not only generically but specifically identical. Another type which in all probability belongs to this species is *Palæacodon vagus.* This latter consists of three superior molars of the right side in perfect condition. In no specimen of the fifty or more individuals of *Omomys Carteri* contained in the Marsh collection are there upper and lower teeth in association, and I base my opinion that these superior molars of *Palæacodon vagus* are the upper teeth of *O. Carteri* upon the following considerations: In a closely allied species of the same genus, *O. pucillus*, in my own collection, there are upper and lower teeth which were found together in such a way as to render it reasonably certain that they belong to the same individual; there is a decided resemblance between the structure of the corresponding teeth of the two forms; in size the teeth of *P. vagus* correspond almost exactly with what the upper teeth of *O. Carteri* should be, as indicated by the relative measurements of the upper and lower teeth of *Hemiacodon gracilis*, *Tarsius spectrum*, and *Anaptomorphus homunculus*, in all of which the upper teeth are known; they do not agree in size with the lower teeth of any other known species of Bridger Primate. I therefore conclude that the type of *Palæacodon vagus* refers to the upper teeth of *Omomys Carteri.*

Description of the Type of Hemiacodon nanus.

The specimen upon which Professor Marsh established this species consists of a fragment of a right mandibular ramus, figure 120, containing the fourth premolar and all three molars in perfect preservation. The crown of the fourth premolar when seen from above has a somewhat squarish outline, slightly wider behind than in front, and is composed of a main central pointed cusp which arises a little above the level of the cusps of the molars. Upon the outside this cusp is convex, and internally

somewhat concave. A sharp ridge descends from the apex of the main cusp in front, curving gently inward to terminate at the base of the crown in a small, though distinct, anterior cusp developed from the cingulum. Posteriorly the principal cusp is flattened in such a manner as to present a triangular face looking upward and backward. Upon the descending ridge forming the inner border of this triangular area is a small, but distinct, internal cusp, which stands internal and posterior to the main cusp. The posterior face of the crown descends steeply to an indistinct ledge at the base, which is the rudiment of the heel. There are no additional cusps developed, however, in this situation, and the heel may be said to be practically rudimental or absent. It is a matter of importance to note the relations of the cusps, since they serve to explain the structure of the succeeding molars. There is a slight cingulum surrounding the base of the crown in front.

The first and second molars are of nearly equal size, and like those of so many other primitive Primates their crowns are composed of an anterior, narrow, triangular portion bearing three cusps—the trigon, and a broader posterior basin-shaped moiety—the heel. The trigon of the first molar is most distinct, and the three subequal cusps are arranged in the form of an equilateral triangle. If the external cusp is taken as the apex, the base coincides almost exactly with the tooth line. It results from this arrangement that the internal cusp is situated posterior and internal to the external cusp, which corresponds to, and is strictly homologous with, the main cusp of the premolar in advance. The anterior cusp of the trigon is well developed, of a distinctly conical form, and projects slightly forward in advance of the crown. The heel broadens rapidly, and is composed of a large V-shaped external, and a smaller, more or less conical, internal cusp, inclosing a depression or valley. This valley is completed behind by two ridges passing inward and backward from the two cusps of the heel. At the angular point where these two arms meet, a slight swelling of the enamel occurs, which may be spoken of as an additional cusp.

120

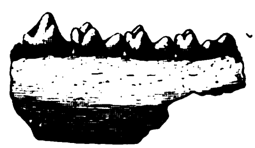
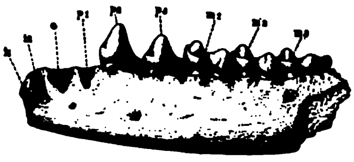


FIGURE 120.—Fragment of a right lower jaw of *Omomys Carteri* Leidy (type of *Hemiacodon nanus* Marsh); inside view; two and one-half times natural size.

The second molar differs but little from the first, the only noticeable variation being that the anterior cusp of the trigon is considerably smaller, less conical, and occupies a more posterior position. The external and internal cusps of the trigon are likewise more nearly opposite each other, or transverse to the long axis of the jaw.

The third molar differs from the two in advance of it in showing a still further reduction of the anterior cusp of the trigon, which can hardly be said to be distinct, as well as the presence of a well-developed third cusp and a more elongated

121



122

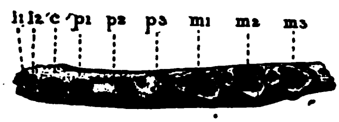


FIGURE 121.—Left lower jaw of *Omomys Carteri* Leidy; showing the alveoli for front teeth; external view; two and one-half times natural size; drawn from two specimens.

FIGURE 122.—Crown view of the preceding figure; two and one-half times natural size.

heel. It is also noticeably narrower, and in many respects distinctly smaller, than the anterior molars. The heel has a large submedian cusp, which stands a little nearer to the inner than to the outer side of the crown.

From the great number of additional specimens of this species in the collection, it is possible to learn the exact dental formula of the lower jaw, which is shown in the accompany-

123

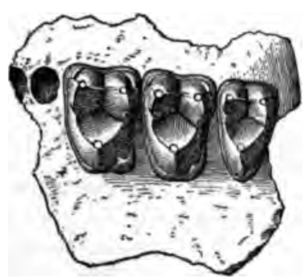


FIGURE 123.—Crown view of three superior molars of *Omomys Carteri* Leidy (type of *Palæacodon vagus* Marsh); four times natural size.

The cingular cuspule internal to the main antero-internal cusp of the first molar is worn away in the specimen, and has not been indicated by the artist with sufficient distinctness. The external cusps are more flattened externally than is shown in the drawing.

ing cuts, figures 121 and 122. There is no specimen in which the crowns of the incisors, canines, or first (second) premolar are preserved, but that of the second (third) is shown in several examples. Its chief characters are as follows:

There is a single high pointed cusp, which rises considerably above the remaining teeth; there is no internal nor ante-

rior cusp; the heel is little developed, and there is a faint indication of a cingulum in front.

The premolar in advance of this, which is really the second according to the proper enumeration, has a single fang distinctly smaller than that of the canine. The two incisors, as determined by their alveoli, were also smaller than the canine, and had an erect position as in the monkeys, not procumbent as in the lemurs. In one specimen, the first is shown to be a little larger than the second, as in some monkeys. The mandibular rami were never coössified.

Description of the Type of Palæacodon vagus.

Of the upper teeth, the molars, figure 123, alone are known, if my determination that those of *P. vagus* refer to *Omomys Carteri* is correct. From what has just been said, I think there can be little doubt of this. The first molar is the largest of the series, and its more or less rectangular crown is made up of three principal cusps arranged in the form of a triangle, of which two are external and one is internal. The external cusps are imperfectly conical, slightly flattened on the outside, and connected with the internal by two distinct ridges (the trigonal ridges), upon which near the middle are developed two small, indistinct, intermediate cusps. The large internal cusp is imperfectly V-shaped, and around the inner side of its base there is a strong cingulum. Posterior and internal to this cusp, the cingulum develops a considerable swelling, which is the beginning of the posterior internal cusp of the higher monkeys. It is built out in such a way as to give a decidedly rectangular appearance to this part of the outline of the crown. This aspect is augmented by the unusual development of the cingulum at the antero-internal angle, where it likewise develops a small, though distinct cusp. In the second molar, which is slightly smaller than the first, the structure of the crown, as well as the arrangement of the cusps, is essentially the same. The postero-internal cusp is, however, not so well developed, and the internal outline of the crown is more rounded and less angular than that of the first molar. The last upper molar is reduced to about the same degree as that of the lower jaw. The intermediates of this tooth are very indistinct, and the internal cingulum is little developed. The inner part of the crown is narrower and more pointed.

The premolars are unknown, but in the type specimen the fangs of the fourth are to be seen. These consist of two external and one internal, as in the molars. Of the two external roots, the posterior seems to be the smaller.

The vertical range of this species is great, and specimens occur from the lowest to the highest levels of the beds.

[To be continued.]

ART. III.—*The Initial Stages of the Spine on Pelée;* by T. A. JAGGAR, JR., Cambridge, Mass.

DR. HOVEY'S interesting studies* of the remarkable spine which has been developed on the summit of the new cone of débris on Mt. Pelée, in Martinique, recall to the writer certain notes and photographs made soon after the first eruption in 1902. These notes are of some interest in the light of Hovey's discoveries, and they are presented here as representing what is perhaps the first record made in the field of the process of spine-growth. A theory of origin for such spines was crudely framed at the time, but many details were obscure. Hovey's article has cleared up some of these points, and an explanation of the phenomenon is here suggested, partly at variance with the theory of the French geologists.†

The First Observed Spine.

On May 21, 1902, the most distinctive features of the inner cone were its low relief relative to the walls of the gorge, and the materials of which it was composed. It appeared to be a heap of scaly or crusty bowlders, "smouldering" in appearance, brown dust clouds rising from the crevices between the fragments. The cone had a rounded crest and its height above its apparent base was not more than 400 feet. The old rim of the basin at the head of the Rivière Blanche rose above it; the diameter of this basin appeared to be about 800 feet.

On June 27th, 1902, from Carbet, the cone was seen to have grown to a height somewhat above the rim of the gorge. The mountain at that time was almost continuously capped with a rain-cloud; for a few minutes that afternoon, however, it partially cleared, and the detail of the cone's slope was seen with a Zeiss binocular to consist of large fragments of brownish angular material resting on a bed of apparently finer gravel. The reddish dust 'cauliflowers' accumulated about every half-hour and rolled down the gorge of the Rivière Blanche from the cone. Sometimes this phenomenon was followed by a low rumbling roar. This suggested that avalanches of loose rock and gravel were falling, either from the rim of the crater or the slopes of the cone. The basin had certainly caved in more or less since May 21st, for it was much wider, and the cone had gained enormously in both height and breadth. From the Carbet beach, at night, a bright incandescent streak was seen

* E. O. Hovey, The New Cone of Mont Pelé and the Gorge of the Rivière Blanche, Martinique. This Journal, October, 1903, p. 269.

† Hovey, loc. cit. p. 276. Lacroix, Comptes Rendus, Oct. 27 and Dec. 1, 1902.

:ossing the west side of the base of the cone obliquely from)uth to north *upwards.* The glow increased and diminished isibly, and on one occasion a sudden increase was followed by a ımbling sound.

Mention has been made of the scaly appearance of the fragıents on the slope of the cone. They appeared quite similar) the "bread-crust" bomb from Pelée figured in the accompanying photograph (fig. 1). This bomb has the specific

1

Bomb from Mt. Pelée.
(Scales shown are inches and centimeters.)

ravity of andesite, shows a brecciated composition, is semiitreous on the outer surfaces, and is uniformly cracked in eep gashes (4 inches). This structure seems to indicate that ıe outer portion of the block has been plastic, while the ıterior remained a solid rock. Other similar fragments, less eeply fissured, may be found on the slopes of Pelée and oufrière, and these are not hardened spheres of molten lava, ut angular pieces of old volcanic rocks. The presence of umice among the products of Pelée's eruptions does not of ecessity imply a new lava; much of the ancient material is umiceous. These bread-crust bombs, however, are not made f pumice, but consist of hard crystalline andesite, frequently ontaining inclusions.

On July 6th, 1902, at 7 A. M., the writer had the good fortune to see the whole cone clear of clouds for about ten minutes. The viewpoint was St. Pierre, and others of the party were E. C. Rost, photographer, E. Lavénaire of the Government office of Martinique, and L. Weisberg, correspondent of the New York Sun. Photographs were secured by Mr. Rost, in sequence, showing the successive stages of development of the cloud-cap on the crater. One of these photographs is here reproduced, showing the volcano at the moment

2

The Spine ; July 6, 1902.

when the complete inner cone came into sight (figs. 2 and 3). Brown dust was rising in purling jets all over the surface, and heavier billows of white steam rose from the southeast side of the cone. Other steam-jets were observed in the Rivière Blanche.

On the summit of the cone was seen a most extraordinary monolith, shaped like the dorsal fin of a shark, with a steep and almost over-hanging escarpment on the east, while the western aspect of the spine was curved and smooth in profile. The field glass showed jagged surfaces on the steeper eastern side, and long smooth striated slopes on the western. Other horn-like projections from the cone could be discerned with difficulty on its slopes lower down. Similar horns were noted by Heilprin in August.* The great spine on the summit was not less than 200 feet high above the surface of the cone.

* Hovey, loc. cit. p. 272.

Mt. Pelée, looking N.E. July 6, 1902.

The Spine of 1903.

Comparing this spine with the greater one figured by Hovey* from photographs taken in March, 1903, it will be seen that it faces in the opposite direction, i. e. the steep scarp in Hovey's pictures faces west, in our photograph it faces east. In both cases there is a long curved constructional slope on one side and a broken cliff of destruction the other. Hovey has pointed out that the later spine was probably the product of conditions developed after August 30th, 1902. The two eruptions of July 9th and August 30th, 1902, were sufficiently violent to destroy the spine observed July 6th, by the present writer.

The steep cliff is clearly in both cases a destructional surface from which material has fallen away. The evolution of the later spine as observed by Major Hodder†, changing from the "lighthouse" shape to the "church steeple" (shark's fin) shape, seems to the writer to imply the blowing off or caving in of one side of a conical mass at first symmetrical about a central vent. This would account for the absence, noted by Hovey‡, of any "definite conduit through the spine itself," and the occurrence of heavy outbursts "from the southwest side of the cone near the base of the spine". The channel for such outbursts, at the base of the *steep* side of the spine, is the original central conduit of a domical mass which has completely caved in on one side, leaving the infacing spine as a half broken-down remnant. The process of breaking down may be gradual, and the upthrust from below may continue to act on the half destroyed residual spine. This will account for gradual changes of shape and fluctuations in elevation of the spine. The striated surface, if this explanation be correct, should be found on all sides of the monolith during the continuance of the "lighthouse" stage. This stage may be restored to the profile shown in the photographs by imagining the smooth curve repeated on the steep side of the spine so as to give it a sugar-loaf shape. Thus in July, 1902 (figs. 2 and 3), the east side of the sugar-loaf had been blown away or had flaked off; in March, 1903, the west side had been removed as shown in Hodder's diagrams.§

Granting that these horns are broken remnants of hard cone-shaped protuberances from the new pile of débris in the crater-gorge, there remains the question of the origin of these protuberances. They have dike ribs extending from them, and are composed of hard rock, fissured and glowing at times, but without associated lava *streams* of any sort. The cumulo-volcano

* This Journal, figs. 1 to 7, October, 1903.
† Hovey, loc. cit. pp. 273–275, and figs. 2 and 3.
‡ Loc. cit. p. 279. § Loc. cit.

theory of Lacroix supposes a "lava" to have risen from the deep regions to furnish material for the spine. This "lava," nearly congealed, "seems to have been pushed up bodily into its present position, and to be maintained there, somewhat like the stopper in a bottle, by friction against the sides of the neck and by the expansive forces underneath."* There can be no question of the evidence that shows the spine to have been pushed up in a semi-solid condition through fissures in the cone of débris. We may ask, however, this question,—may not the half-molten substances be a superficial product, resulting from the mechanical and thermal conditions that governed the building of the cone?

The writer's reasons for opposing the "lava" hypotheses are twofold: (1) None of the ejecta of Pleistocene times in the Caribbees are true lavas; (2) Even the more ancient geologic sections show few flows. If lavas are to flow from Pelée at this time, then these eruptions inaugurate a new era. This is improbable, for there have been eruptions in these islands averaging once in twenty-three years for over 300 years of human record, and the eruptions of the unrecorded previous centuries left no lava flows on the present or recent topography. The ejecta collected from the present and past historic eruptions are fragments of ancient andesites and basalts.

Theory of Origin of Spine.

The following is a suggested explanation of the origin of the spines, which does not require a flowing lava to rise into the throat of the volcano from deep-seated sources:—

The spines are small compared to the volume of material which has fallen back into the crater from many successive eruptions. This material fills not only the crater-gorge of the Rivière Blanche, but deep fissures of unknown size beneath the present cone. Such fissures have been enlarged below with every eruption, while at the same time bombs have been heaped upon the cone above.

The rocks ejected were observed to become more incandescent with successive eruptions and much of that which fell back on the cone consisted of large fragments half molten on the surface; there was much finer material mixed with these.

Accumulation of this pasty incandescent material with each new eruption produces increased pressure from above, and by conduction and radiation the heat is probably concentrated. The outer portions of the cone become crusted, a blast of hot gases and the steam traverses the open passages, and both

* Hovey, loc. cit., p. 278.

chemical and mechanical conditions favor the fusion and segregation within, of the more fusible minerals.

Rifting of the crust may take place by faulting, differential contraction, or by the action of escaping steam, and the molten matter slowly wells up under the pressure of the slumping agglomerate.

Exposed to the cooler air this viscid silicate mixture solidifies quickly and impedes the upward progress of the more liquid portions below.

The actual volume of the molten material would increase with many successive eruptions and diminish with cessation of eruption: it would *vary with the growth of the cone*, and this is what the spines have been observed to do. There can be no doubt that an enormous amount of red-hot material is confined in the cone and the fissures beneath; that it would remain incandescent for months even without additions is proved by analogy with the banks of hot gravel along the stream courses. These retain their heat for many weeks after an eruption; a rain-crust forms above, and the banked-in gravel causes frequent explosions when ground-water makes contact with it. If these banks so retain their heat at a distance of miles from the crater, much more will the temperatures within the cone be high and long maintained, for there the fragments are hottest and largest, are accumulated in greatest volume, are frequently added to, and are in contact with dust-laden steam and heated gases rising under pressure from unknown depths.

Even if no spines had appeared, one might ask on *a priori* grounds, What has become of all the pasty incandescent material that has fallen back into the crater and is now under pressure? It cannot be supposed to have hardened at once, and it must have been intimately mixed with pulverized rock of varying fusibility. It would seem dynamically probable, therefore, that such material would become agglutinated in fluid masses within the agglomerate of the crater fissure, and escape to form irregular protuberances along paths of least resistance.

ART. IV.—*The Action of the Halogen Acids upon Vanadic Acid*; by F. A. GOOCH and R. W. CURTIS.

[Contributions from the Kent Chemical Laboratory of Yale University—CXXIII.]

IN the study of the interactions between the halogen acids and vanadic acid in solution made chiefly with a view to the analytical applications, it has been shown that if conditions be suitably fixed, vanadic acid may be reduced definitely by hydrochloric acid and by hydrobromic acid to a condition of oxidation corresponding to that of the tetroxide, V_2O_4, and that hydriodic acid may carry the reduction to the stage of the tetroxide or to that of the trioxide, V_2O_3, according to conditions. It is the object of this paper to record some results of further study of the conditions of action between vanadic acid and the halogen acids.

The Reducing Action of Hydrochloric Acid.

It has been shown in an article from this laboratory* that the reaction of the process, according to which a suitable vanadate is treated with hydrochloric acid, the solution boiled, and the evolved chlorine determined as suggested by Bunsen,† noted by Mohr,‡ and utilized by Gibbs,§ is nearly complete in a single operation when the concentration of the hydrochloric acid is sufficient, and that an approximately correct determination of the vanadium may be made by the process when special care is taken to register all the chlorine set free. It appeared, however, that the reaction is reversible, and that in the ordinary process involving a single treatment of the vanadate with strong hydrochloric acid and boiling, the tendency to reverse is not fully overcome. When hydrochloric acid of suitable concentration and the vanadate come to contact, the evolution of chlorine is immediate, some chlorine escapes from the solution, some is retained, and the reaction proceeds to a balance as indicated in the expression

$$V_2O_5 + 2HCl \rightleftarrows V_2O_4 + H_2O + Cl_2.$$

To complete the reduction of the higher oxide it is necessary to remove the free chlorine from the system while keeping up the requisite strength of the hydrochloric acid. In removing the chlorine by boiling, the concentration of the hydrochloric acid is diminished below the point at which action upon vanadic acid may take place with liberation of chlorine. This is why in pushing the action to completion by the boiling process, it is necessary to increase the concentration of the hydrochloric acid from time to time either by cooling and recharging with gaseous acid or by evaporating off the weak acid and replacing it by strong acid.

* Gooch and Stookey, this Journal, xiv, 369 (1902).
† Ann. Chem. (Liebig), lxxxvi, 265. ‡ Titrirmethode, 5te Aufl., 314.
§ Proc. Amer. Acad., xviii, 250.

In continuing the study of this reaction we have thought it desirable to try to effect the removal of the chlorine and to complete the reaction by bubbling a current of gaseous hydrochloric acid through the cooled residue of a single treatment by boiling. Under these conditions the hydrochloric acid must always be at the concentration of activity, though the removal of the chlorine must be slow since the current of gas should not be rapid enough to cause mechanical loss from the mixture.

The apparatus used in these experiments was similar to that employed in the former work to which reference has been made, and is shown in the accompanying figure. We have

used as the source of vanadic acid for the experiments to be described immediately, and throughout this paper, ammonium vanadate of known purity, standardized by the method of Holverscheit.*

In every experiment approximately 0·1 gm. of ammonium vanadate was first introduced into the reduction flask B. The air was expelled from the apparatus by carbon dioxide from the generator, the receiver C being charged with hydrochloric acid and the trap *g* with water. Concentrated hydrochloric acid (15^{cm^3}) was admitted through the stoppered funnel A, and the mixture was boiled. The deep red color produced when the acid was first added, gradually passed through green to blue. The flask was allowed to cool, carbon dioxide being admitted to fill the partial vacuum, and surrounded with ice. Hydrochloric acid gas was passed into the reduction flask, at the rate of one or two bubbles a second, through the solution for periods varying from $\frac{1}{2}$ to $112\frac{1}{2}$ hours, the solution turning brown at first and then changing to green or blue, according to the length of the period. For continuing the flow of gas for long periods small Kipp generators set up with sublimed ammonium chloride in large lumps, and concentrated sulphuric acid, were found very convenient, a single charge serving to keep up the flow continuously over night.

* Inaug. Dissert., Berlin, 1890, p. 48.

At the end of the operation the degree of reduction was determined by titrating the contents of the flask, after dilution, with potassium permanganate in presence of a manganous salt. The data of the experiments are detailed in the following table:

TABLE I.

Exp.	NH_4VO_3 taken. gm.	Time. hrs.	V_2O_4 per 0·1000 gm. of vanadate taken. Calculated.	Found.	Difference.
1	0·1022	½	0·0695	0·0619	0·0076
2	0·1121	17	"	0·0621	0·0074
3	0·1010	18½	"	0·0678	0·0017
4	0·0980	21	"	0·0658	0·0037
5	0·1044	30	"	0·0600	0·0095
6	0·1043	112½	"	0·0691	0·0004

The reduction of the vanadic acid to the condition of the tetroxide by the action of hydrochloric acid in the cold is obviously slow, as would be expected, but the results show that it may be made practically complete in this manner. No indication of reduction below the condition of the tetroxide by the agency of hydrochloric acid is apparent.

The Reducing Action of Hydrobromic Acid.

In Holverscheit's most excellent method for the estimation of vanadic acid the reduction, effected by the action of hydrochloric acid and small amounts of potassium bromide, is almost ideally complete to the condition represented by vanadium tetroxide. Under the conditions the concentration of the hydrobromic acid is low, and it was thought to be of interest to investigate the effect of more concentrated hydrobromic acid upon the course of reduction.

In the first six experiments recorded in the following table, weighed portions of ammonium vanadate were introduced into the reduction flask, the receiver and trap were charged with a solution of potassium iodide (3 gm.: 350^{cm^3}), the apparatus was filled with carbon dioxide, hydrobromic acid (15^{cm^3}) of sp. gr. 1·68 (made by distilling a mixture of potassium bromide and syrupy phosphoric acid) was introduced through the funnel and the mixture was boiled eight or ten minutes. On the addition of the acid the vanadate dissolved and the solution took on a light green color, which on heating changed to red-brown and finally to a clear deep green. After cooling, the degree to which the vanadic acid had been reduced was estimated in two ways—by determining by means of standard sodium thiosulphate the iodine set free in the receiver by the bromine evolved, and by oxidizing by standard iodine the reduced product in the flask. The latter process followed the lines recommended by Browning* and consisted essentially in neutralizing the acid in the reduction flask by potassium bicar-

* Zeitschr. anorg. Chem., xiii, 116.

bonate (in solution 1 : 5), adding an excess of twentieth normal iodine, allowing the mixture to stand twenty minutes (all without admission of air) then transferring to a larger flask, introducing a slight excess of twentieth normal arsenious acid, and titrating to standard blue with iodine.

In experiment (7) the aqueous hydrobromic acid was strengthened by cooling and passing in gaseous acid before boiling; and in experiment (8) the residue in the flask was submitted to several treatments of cooling, recharging with the vapor liberated by heating the strong aqueous hydrobromic acid, and boiling, in order to see the effect of varying the concentration, the bromine evolved by each boiling being determined, and finally the degree of reduction of the residue was estimated as usual. The results of these experiments are calculated upon the hypotheses that the vanadic acid is reduced (first) to the tetroxide, (second) to the trioxide, and (third) that the trioxide and tetroxide are left in mixture.

TABLE II.

Exp.	In 0·1000 NH_4VO_3 taken		Found; calc. as V_2O_4		Found; calc. as V_2O_3		Found; calc. as mixture from figs. for receiver	
	V_2O_4 gm.	V_2O_3 gm.	Flask gm.	Receiver gm.	Flask gm.	Receiver gm.	V_2O_4 gm.	V_2O_3 gm.
1	0·0699	0·0632	0·0913	0·0877	0·0418	0·0396	0·0521	0·0160
2	0·0699	0·0632	0·0879	0·0885	0·0397	0·0400	0·0513	0·0168
3	0·0699	0·0632	0·0849	0·0896	0·0384	0·0405	0·0502	0·0179
4	0·0699	0·0632	0·0858	0·0849	0·0388	0·0384	0·0549	0·0136
5	0·0699	0·0632	0·0854	0·0853	0·0386	0·0385	0·0545	0·0139
6	0·0699	0·0632	0·0841	0·0839	0·0380	0·0379	0·0559	0·0127
7	0·0699	0·0632	0·0945	0·0943	0·0427	0·0426	0·0455	0·0221
8a	0·0699	0·0632	.....	0·0860	.. ..	0·0389	0·0538	0·0146
8b			.....	0·1104	.....	0·0499	0·0295	0·0366
8c			.....	0·1291	.....	0·0584	0·0107	0·0535
8d			0·1258	0·1291	0·0569	0·0584	0·0107	0·0535

So it appears that increase in concentration of the hydrobromic acid tends to carry the reduction below the condition of the tetroxide; but the highest degree of reduction reached in these experiments corresponds to a mixture of one-sixth tetroxide and five-sixths trioxide.

Results somewhat similar were obtained with hydrobromic acid made (first) by acting with bromine upon naphthalene and purifying the gaseous acid by passing it through a column of red phosphorus, and (secondly) by passing the vapor of bromine with hydrogen over hot platinum somewhat after the synthetic method of Harding,* and sending the product through red phosphorus. In a single case in which the synthetic hydrobromic acid was used, the reduction, after three chargings of

* Ber. Dtsch. chem. Ges., xiv, 2085.

the liquid and boiling, apparently reached the stage of V_2O_3, but, inasmuch as the purity of the synthetic hydrobromic acid was not thoroughly established, we do not regard this particular result as wholly trustworthy.

The Reducing Action of Hydriodic Acid.

According to Rosenheim* vanadic acid is not completely reduced to the condition of the tetroxide by the hydriodic acid made nascent when sulphuric acid and potassium iodide interact, analytical results showing an apparent reduction of 80 per cent or less. A comparison of the calculated figures with the recorded amounts of the reagents and their standards raises the question as to whether the standards have not been interchanged in the computation,† and in this event Rosenheim's figures would approximate 100 per cent as nearly as could be expected under the described conditions of manipulation. Friedheim and Euler echo Rosenheim's statement.‡ Browning,§ on the other hand, has shown that good analytical results are obtained when solutions of the vanadate, one or two grams of potassium iodide and 10^{cm^3} of sulphuric acid of half-strength are boiled to a volume of about 35^{cm^3} and the residual solution is cooled, neutralized with an alkaline bicarbonate (after the addition of a tartrate to prevent precipitation) and treated for some time with an excess of iodine which is followed by an excess of arsenious acid, the last being titrated by iodine to the blue end-reaction in presence of starch.

In Browning's process the estimation of the reduced product in the residue is made the measure of action. In section A of the following table are given the results of experiments in which the treatment was conducted in an atmosphere of carbon dioxide and in which the determinations of the iodine collected in the receiver are set over against the determinations of the reduction in the residue by Browning's process, omitting the addition of a tartrate.

In section B are given results of experiments differing from those of section A in that in treating the residue the excess of iodine was added before neutralizing with potassium bicarbonate so that re-oxidation should not be effected in the sensitive alkaline solution by atmospheric oxygen rather than by the iodine which is measurable.

It will be noted that in every experiment the iodine found in the receiver indicates a trifling reduction beyond the condition of the tetroxide V_2O_4, averaging 0·0023 gm.; and the same in general is true in regard to those determinations of

* Inaug. Dissert., Berlin, 1888, p. 18.

† Compare the standard of solutions on p. 15 loc. cit. with the computed results of tables on pp. 15 and 18.

‡ Ber. Dtsch. chem. Ges., xxviii, 2070. § This Journal, ii, 185 (1896).

TABLE III.

Exp.	V_2O_4 in 0·1000 gm. NH_4VO_3 taken gm.	KI gm.	H_2SO_4 1 : 1 cm³.	Initial vol. cm³.	Final vol. cm³.	Reduction flask V_2O_4 Found gm.	Reduction flask V_2O_4 Error gm.	Receiver V_2O_4 Found gm.	Receiver V_2O_4 Error gm.
					A				
1	0·0699	1	10	..	35	0·0668	0·0031–	0·0700	0·0001+
2	0·0699	1	10	..	35	0·0692	0·0007–	0·0715	0·0016+
3	0·0699	1	10	..	35	0·0686	0·0013–	0·0718	0·0019+
4	0·0699	1	10	50	35	0·0696	0·0003–	0·0744	0·0045+
5	0·0699	1	10	45	35	0·0678	0·0021–	0·0704	0·0005+
6	0·0699	1	10	50	35	0·0690	0·0009–	0·0710	0·0011+
7	0·0699	1	10	60	35	0·0681	0·0018–	0·0738	0·0039+
8	0·0699	1	10	55	35	0·0689	0·0010–	0·0724	0·0025+
9	0·0699	·6	6	55	35	0·0679	0·0020–	0·0722	0·0023+
					B				
10	0·0699	1	10	55	35	0·0699	0·0000±	0·0713	0·0014+
11	0·0699	1	6	55	35	0·0713	0·0014+	0·0722	0·0023+
12	0·0699	1	10	80	35	-----	-----	0·0725	0·0026+
13	0·0699	1	10	75	35	0·0710	0·0011+	0·0718	0·0019+
14	0·0699	·6	4	55	35	0·0701	0·0002+	0·0709	0·0010+
15	0·0699	·6	10	55	35	0·0717	0·0018+	0·0745	0·0046+
16	0·0699	·6	6	55	35	0·0706	0·0007+	0·0734	0·0035+
17	0·0699	·6	6	55	35	0·0703	0·0004+	0·0727	0·0028+
18	0·0699	·6	4	55	35	0·0700	0·0001+	0·0731	0·0032+

the residue in the reduction flask, in which the iodine was added before the bicarbonate—the over-reduction in the residues of section B averaging 0·0007 gm. The determinations of reduction in the residue, in the series of section A, in which the neutralization took place before the addition of the iodine, uniformly show an incomplete rednction—amounting in the average to 0·0015 gm.—an effect which is without doubt due to the action of air upon the sensitive alkaline solution of the reduced vanadate.

It appears, thus, that under conditions of concentration in which in absence of the vanadic acid there is no tendency (barring the insignificant action of dissolved air) toward liberating iodine, a little more iodine is liberated by vanadic acid when acted upon by sulphuric acid and potassium iodide than would correspond to a reduction of vanadic acid to the condition of the tetroxide.

Concerning the action of concentrated hydrochloric acid and potassium iodide upon a vanadate, Friedheim and Euler* give analytical data which go to show that reduction of the vanadic acid goes nearly (97.2 per cent) to the condition of the trioxide V_2O_3, and venture the assertion that the incompleteness of the reaction is conditioned by the formation of an oxyiodide which is broken up by the hydrochloric acid

* Ber. Dtsch. chem. Ges., xxviii, 2071.

only at a concentration (volume) which can not be reached without danger to the retort in which the operation is conducted. Friedheim and Euler propose the addition of phosphoric acid to this end and give excellent analytical results to sustain the suggestion.

In the experiments of the following tables, made in the apparatus figured and described above, the reductions were

TABLE IV.

Exp.	V_2O_5 in 0·1000 NH_4VO_3 taken gm.	HCl conc. cm³.	KI gm.	Initial vol. cm³.	Final vol. cm³.	V_2O_3 found Flask	Receiver
			A				
1	0·0632	5	0·6	50	*	....	0·0323
--	....	--	--	--	2	0·0613	0·0627
2	0·0632	5	1	55	*	....	0·0327
--	....	--	--	--	2	0·0618	0·0637
3	0·0632	12·5	1	50	*	....	0·0378
--	....	--	--	--	2	0·0615	0·0644
4	0·0632	15	1	45	*	....	0·0372
--	....	--	--	--	2	0·0617	0·0642
5	0·0632	25	1	50	*	....	0·0518
--	....	--	--	--	2	0·0618	0·0657
			B				
1	0·0632	15	1	16	2	0·0618	0·0630
2	0·0632	--	--	--	--	0·0612	0·0627
3	0·0632	--	--	--	--	0·0617	0·0625
4	0·0632	--	--	--	--	0·0620	0·0630
5	0·0632	--	--	--	--	0·0616	0·0627
6	0·0632	--	--	--	--	0·0618	0·0628
7	0·0632	--	--	--	--	0·0617	0·0630
8	0·0632	--	--	--	--	0·0617	0·0629
9	0·0632	--	--	--	--	0·0616	0·0629
10	0·0632	--	--	--	--	0·0618	0·0630

made by the action of hydrochloric acid and potassium iodide. In series A varying concentrations were employed and the boiling was interrupted as soon as the vapor of iodine had disappeared from the flask and the contents of the receiver titrated without admitting air. The receiver was then replaced, the boiling continued until the volume remaining was about 2^{cm^3}, when the free iodine in the receiver and the reduced product in the flask were determined. In series B the boiling was carried at once to the final stage.

From these results it is apparent that the degree to which vanadic acid may be reduced by hydrochloric and hydriodic acids turns upon the concentrations. We have found no difficulty in carrying the reduction, in the apparatus described, to

* To the point when the vapor of iodine had disappeared from the flask—approximately 40^{cm^3}.

the condition of the trioxide without the addition of phosphoric acid. In fact, the presence of phosphoric acid may work disadvantageously when low volumes are reached by permitting a dangerous rise of temperature in the still liquid residue. This is shown in the following series of experiments in which 1 gm. of potassium iodide, 2^{cm^3} of syrupy phosphoric acid (sp. gr. 1·70) and 0·1 gm. ammonium vanadate were treated, the initial volume being 60^{cm^3}.

TABLE V.

Exp.	In 0·1000 NH_4VO_3 taken		Final vol.	Reduction flask		Receiver	
	V_2O_4 gm.	V_2O_3 gm.	cm^3.	As V_2O_4	As V_2O_3	As V_2O_4	As V_2O_3
1	0·0699	0·0632	35	0·0693	....	0·0698	....
2	0·0699	0·0632	25	0·0705	....	0·0711	....
3	0·0699	0·0632	22	0·0711	....	0·0706	....
4	0·0699	0·0632	4	....	0·0606	....	0·0623
5	0·0699	0·0632	2	....	*	....	0·0617
6	0·0699	0·0632	2	....	0·0597	....	0·0612
7	0·0699	0·0632	1·7	....	0·0621	....	0·0613
8	0·0699	0·0632	1·6	....	*	....	0·0624
9	0·0699	0·0632	1·4	....	0·0604	....	0·0629

These figures indicate also that when the distillation is continued until the volume is about 35^{cm^3}, the condition of oxidation corresponds nearly to that of the tetroxide. When the residue is concentrated almost to dryness, the figures approach the value for the trioxide, but under the conditions they are of doubtful value; for, fumes of hydriodic acid are visible in the flask, more or less spattering occurs, and the temperature is such that a volatile compound of vanadium begins to distil.

In summary of the work described it may be pointed out that in the interaction of hydrochloric, hydrobromic, and hydriodic acids upon vanadic acid the degree to which the last is reduced depends, as would be expected in reversible reactions, upon the concentrations. It has been shown that hydrochloric acid is capable of carrying the reduction, even in the cold, to the condition of the tetroxide, and under none of the conditions tried does reduction go further: that hydrobromic acid, which in small concentrations gives a definite reduction to the condition of the tetroxide, may easily push the reduction well on toward the condition of the trioxide: that the reduction by hydriodic acid may be carried at will to either of the stages—that of the trioxide or that of the tetroxide.

* Flask broke.

Art. V. — *Development of some Paleozoic Bryozoa;* by Edgar Roscoe Cumings.

Introduction.

The development of Paleozoic Bryozoa has up to the present time received very little attention. The few scattering observations of Lindström,[18] Nicholson,[24] Shrubsole,[41] Vine,[47] and Ulrich,[44] leave the knowledge of the subject practically where it was at the outset. Nicholson devotes a chapter to a discussion of the development of the Monticuliporidæ, but does not go further than a criticism of the views of Lindström, in regard to the supposed ontogenetic relationship between *Monticulipora* and *Ceramopora.* Shrubsole's notions of the development of *Fenestella* are entirely erroneous, those of Vine are but little better, while Ulrich concurs with Nicholson in rejecting the views of Lindström.

The writer's researches during the past year, at the Yale University Museum, have resulted in the discovery of many unique facts bearing upon the development of certain Paleozoic and recent Bryozoa. Although this investigation is still in progress, it will not be out of place to present some of the results thus far obtained, reserving the details for monographic treatment later.

All the material used in this investigation of the development of *Fenestella*, *Polypora*, *Unitrypa*, *Hemitrypa*, *Paleschara*, etc., belongs to the collection of the Yale University Museum. The silicified Lower Helderberg and Hamilton Bryozoa were especially collected by Dr. C. E. Beecher with reference to the study of the stages of growth. Dr. Beecher has not only placed all this unique material at the writer's disposal, but has in every possible way lent his aid and encouragement to the work. For this aid, as well as for his profound interest in the difficult and too often neglected problems of paleobiology, the writer is deeply grateful.

General.

The development of recent Bryozoa has been studied by a large number of observers, among whom J. Barrois,[1-4] Calvet,[5a] Claparède,[6] Harmer,[9-12] Joliet,[15,16] Metschnikoff,[21-23] Ostroumoff,[27] Pergens,[28] Prouho,[29-31] Repiachoff,[32-38] Seeliger,[40] Smitt,[43] and Vigelius[46] have contributed the most important results for the presedentary stages; and Barrois,[1] Nitsche,[25,26] Braem,[5] Davenport,[7,8] and Harmer,[11,12a] for the early budding stages of the colony. While the latter are necessarily the only ones ever preserved as fossils, a brief review of the earlier development will help to make the discussion of the later much more intelligible.

The now generally accepted classification of the stages of growth and decline, proposed by Alpheus Hyatt,[18] has never been consistently applied to a colonial organism, such as are the Corals and Bryozoa, nor to one whose ontogeny presents the retrograde metamorphosis which characterizes the latter class. It must be borne in mind that a colony or stock composed of a number of individuals may be properly characterized as nepionic, while some of the individuals composing it are in reality mature, senile, or even dead. The nomenclature of Hyatt applies solely to an individual developing from an ovum, that is, in the case of the Bryozoa, to the *first individual of the colony*. It follows, therefore, that before the colony has reached a stage in which its genus or even its family is recognizable, the first zoœcium, which the author here proposes to designate as the *protœcium*,* has become mature (ephebic). The colony would thus be phylembryonic,† while the protœcium is ephebic. Probably no confusion would arise from this source, if the exact sense in which these terms are used in a specific case, whether as applying to the individual or to the colony, were distinctly stated. Since the development of a bud presents no parallel with the early stages in the development of an individual from an ovum, there can be no confusion of terms up to and including the typembryo. It will be convenient, therefore, to have for the growth stages of a colony a nomenclature which entirely avoids the confusion attending the use of the terms nepionic, neanic, etc. Hence, the writer would submit the following set of terms, composed of the appropriate age-indicating word, as above, combined with the Greek word ἄστυ (*ăsty*), a town or assemblage of dwellings: thus, *nepiasty*, *neanasty*, *ephebasty*, and *gerontasty*, meaning an infant, adolescent, mature, or senile colony; and *nepiastic*, *neanastic*, *ephebastic*, and *gerontastic*, the corresponding adjectives.

Description of Figures 1–15.

Figures 1–15.—Development of a Chilostomatous Bryozoan, *Schizoporella unicornis*. (After Barrois.)

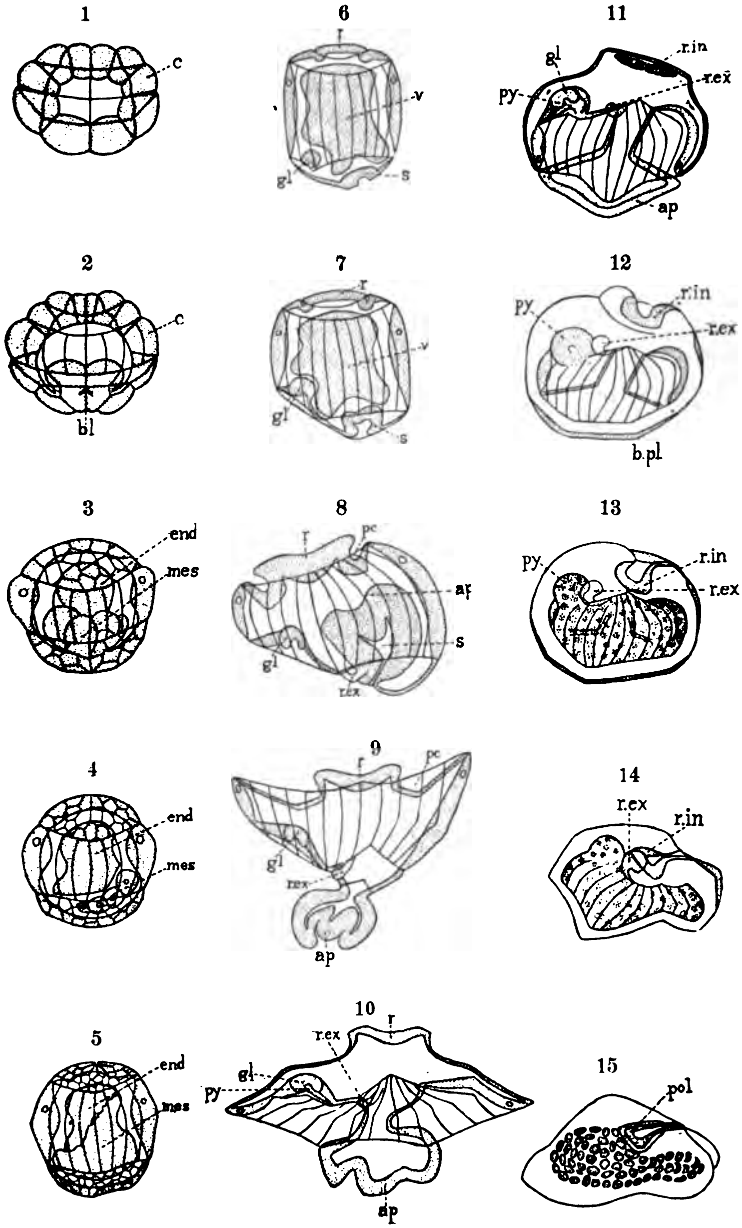
1. Mesembryo; 2. Metembryo; 3–5. Formation of the endoderm‡; 6, 7. Intermediate stages in the formation of the free-swimming larva; 8. Normal larva; 9. Evagination of the adhesive organ; 10. Reversal of the mantle; 11–14. Degeneration of the larval organs during the first sedentary stages; 15. First appearance of the polypide stage corresponding to fig. 26.

c, coronal cells; *bl*, blastopore; *end*, *mes*, endoderm; *r*, retractile disc; *s*, *ap*, adhesive organ (adhesive plate); *gl*, *py*, pyriform organ; *r.in*. rudiment of polypide; *pol*, polypide (double vesicle stage of Calvet[5a]).

All figures × 110.

* From πρῶτος, first, and οἰκίον, house or abode. † Jackson.[14]

‡ The investigations of Calvet[5a] have disproven the views of Barrois regarding the differentiation of the endoderm and mesoderm and the fate of the part marked *r.ex* in the figures. Nevertheless his figures present the general course of development with such clearness that it has seemed best to reproduce them and call attention to the points which lack full confirmation.



(For description see preceding page.)

I. *Classification of the Stages of Growth.*

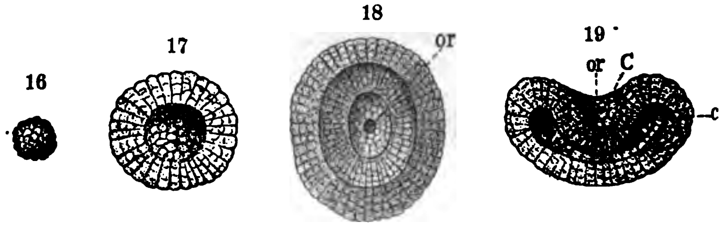
Embryonic Stages.

The *protembryo* includes the ovum and its segmented stages up to the formation of the blastula. Cleavage is total and almost equal (Korschelt and Heider[17]). The animal and vegetative poles can be distinguished by a slight difference in the size of their respective blastomeres.

The *mesembryo* (blastula) (fig. 1) is of lenticular shape, with a fair-sized cleavage cavity.

The *metembryo* (gastrula) (figs. 2, 3) is formed by the ingression of four endoderm cells. The coronal cells are defined at this stage (*c*, fig. 2) and later become very conspicuous. The four endoderm cells multiply so as to completely fill the blastocœle, thus forming a planula.

The *neoembryo* (figs. 4–8 and 17–25) includes the stages from the formation of the planula to the completed free-swimming larva (fig. 8). During these stages the endodermal cells multiply, according to Barrois[3] differentiating into endoderm and meso-



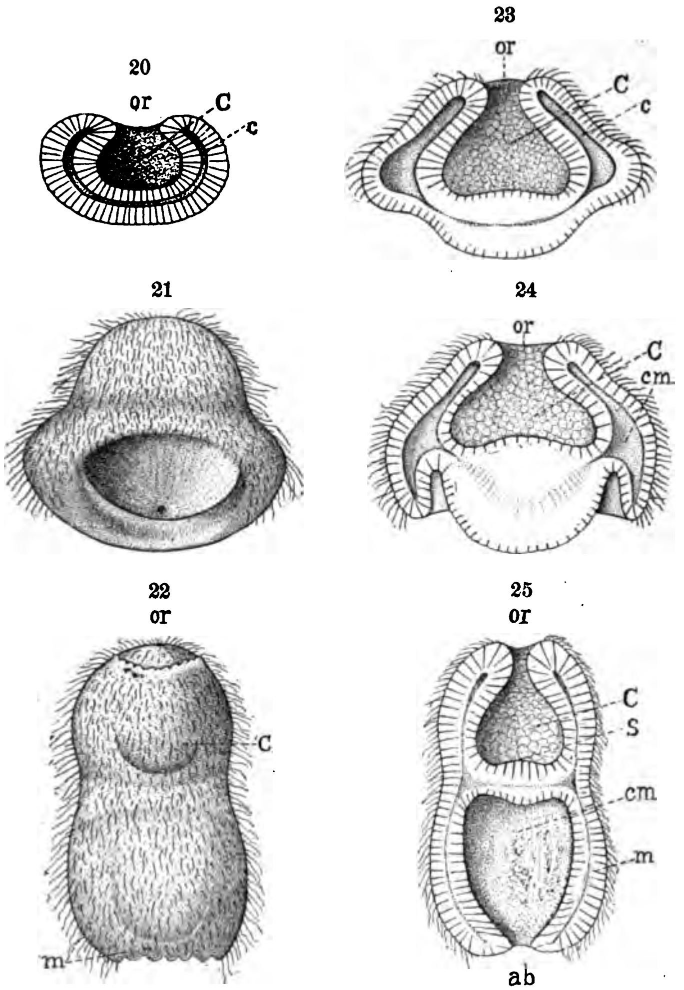
FIGURES 16–19.—Early embryonic stages of a Cyclostomatous Bryozoan, *Phalangella* (=*Tubulipora*). (After Barrois.)
16. Metembryo (pseudoblastula); 17, 18, 19. (Pseudogastrula) invagination of the adhesive organ; stages corresponding to figs. 6 and 7.
or, oral region; *C*, invagination cavity.
Figure 16 ×300; figures 17–19 ×160.

derm* (figs. 4, 5). The cells of the corona increase in size and become covered with cilia; a disclike thickening bearing stiff setæ, the retractile disc, develops in the aboral half. This is encircled by a depression,—the mantle cavity. An invagination develops in the posterior portion of the aboral half, to form the sucker, or adhesive organ (*ap*). An alimentary canal may develop at this stage in some types of larvæ (see figs. 31–35 and 22, 25).

The *typembryo* (figs. 9, 10) is formed by the evagination of the adhesive organ and reversal of the mantle (fig. 10). This gives rise to the first sedentary stage, which is passed through with great rapidity, and is immediately succeeded by a complicated metamorphosis involving the degeneration of most of the larval organs.

* This has not been observed by other workers.

This metamorphosis, or *kathembryonic** stage, is not present in those organisms which pass directly from the larval to the



FIGURES 20–25.—Further stages in the formation of the free-swimming larva of *Phalangella* (=*Tubulipora*). (After Barrois.)

24 and 25. Optical sections of 21 and 22 respectively; 23. Beginning of formation of the mantle; 22 and 25. Completed larva.

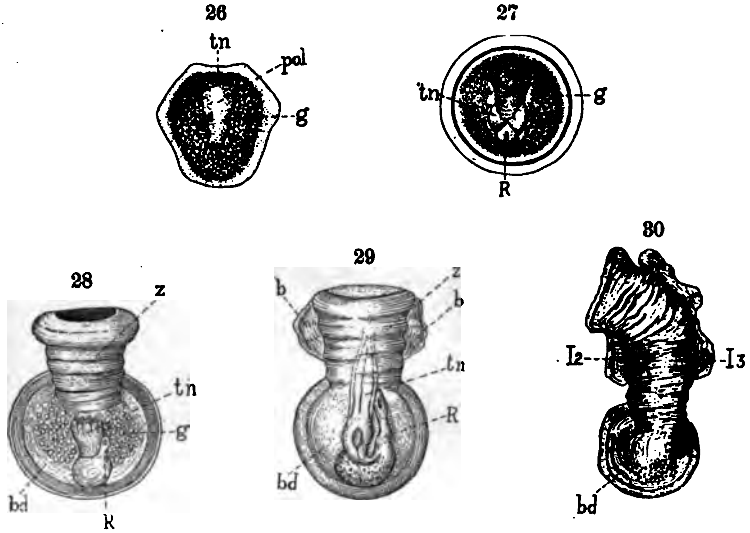
or, oral region; *C*, invagination cavity of adhesive organ; *S*, adhesive organ (sucker); *cm*, mantle cavity; *m*, mantle.

Fig. 25 is modified from Barrois' original figure, in accordance with his later views.

All figures × 160.

* κατά, in the sense of opposition or contrast.

adult type of structure (Brachiopoda, Mollusca, etc.). The term is here proposed to cover the complicated degenerative metamorphosis of the Ectoproctous Bryozoa (figs. 11–15 and 26). During this stage the margin of the reversed mantle fuses with the margin of the extended and flattened adhesive plate, and the corona, pyriform organ, and larval intestine (where present) degenerate, forming a mass known as the brown body. The secretion of the ectocyst begins at this stage. The



FIGURES 26–30.—Formation of the polypide and protœcium in *Phalangella* (= *Tubulipora*). (After Barrois.)

26. An early sedentary stage, showing rudiment of polypide; 27. Beginning of tentacles and first zoœcium (protœcium); 28–30. Formation of first mature individual and primary buds, I_2 and I_3.

pol, polypide; *tn*, tentacles; *g*, globules formed by degeneration of larval organs; *R*, rectum; *z*, zoœcium; *b*, *b*, primary buds; *bd*, basal disc.

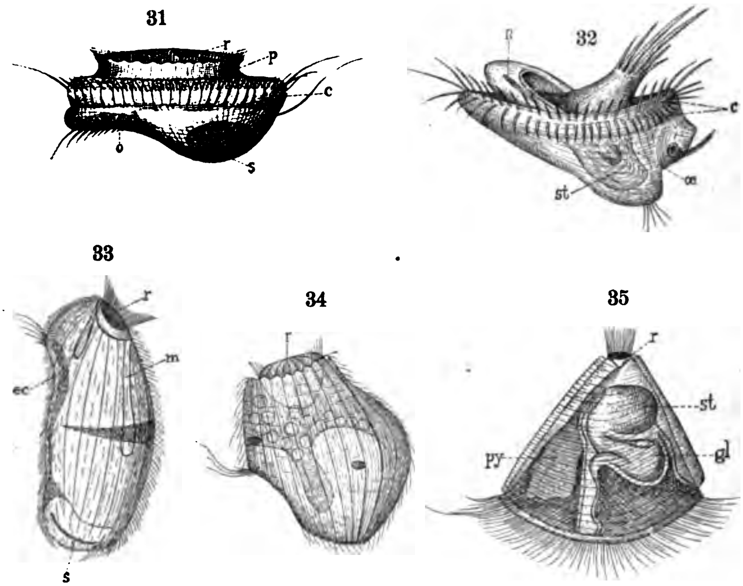
Figures 26–29 × 55; figure 30 × 40.

retractile disc is invaginated, and becomes the rudiment of the future polypide.*

The *phylembryo* (fig. 27) is characterized by the first appearance of the lophophore, the secretion in most types of a chitinous or calcareous investment, and the origin of the true alimentary canal. This is the earliest stage capable of fossilization. It closes with the origin of the primary buds. This first zoœcium of the colony is called the *protœcium*, or primary dwelling. The term *protœcium*, therefore, will not be exactly cognate

* According to Barrois[2] a paired organ (*r.ex.* figs. 8–14) shares in the formation of the polypide. On this subject, see Ostroumoff,[27] Vigelius,[46] Calvet,[5a] and Prouho[29] for a different view. See also the interpretation of the metamorphosis given by Harmer[12] and Sedgwick.[39]

with the terms *protegulum*, *protoconch*, *protaspis*, etc., as applied to the Brachiopoda, Cephalopoda, and Trilobita, respectively; for the latter terms signify the initial shell or covering of the individual and are not concerned with the adult, while the protœcium is the *initial zoœcium* of the colony and belongs to all growth stages of the initial polypide later than the kathembryo. From the standpoint of the colony the stage represented by the protœcium is *phylastic* (figs. 27–30).



FIGURES 31–35.—Types of free-swimming larvæ. (Figures 31, 32, 34, 35, after Barrois; figure 33, from Korschelt and Heider, after Barrois.)

31. Larva of *Alcyonidium*, a type which develops an alimentary canal; 32. Larva of *Loxosoma;* 33. Larva of *Serialaria*, vesicularian type; 34. Larva of *Bugula*, intestineless Chilostomatous type; 35. Larva of the *Cyphonautes* (*Membranipora*).

r, retractile disc; *p* and *m*, mantle cavity; *c*, coronal cells; *o* and *py*, pyriform organ; *s*, adhesive organ (sucker); *gl*, glandular organ; *st*, stomach; *R*, rectum; *œ*, œsophagus.

Figure 31 ×100; figure 32 ×116; figure 33 ×120; figure 34 ×133; figure 35 ×66.

The early development of the Cyclostomata presents some peculiarities that led Barrois[1] to mistake the metembryo (fig. 16) for a morula, and the early stages of the invagination of the adhesive organ (figs. 17–19) for a gastrula. This mistake has been repeated in a recent memoir on fossil Bryozoa. The development of the Cyclostomata, as pointed out later by Barrois,[4] Ostroumoff,[27] and others, quite closely parallels the development of the Chilostomata. The metamorphosis is similar.

Fig. 25 has been modified from Barrois' original figure in accordance with his later views.[4] The differences in the development of the Cyclostomata and Chilostomata consist mainly in the small size of the adhesive organ in the former, and the great size of the sucker invagination, together with the vestigial condition of the retractile disc and absence of the pyriform organ. The cylindrical shape of the Cyclostome larva is paralleled among the Chilostomata by *Serialaria* (fig. 33).

Classification of the Growth Stages of the Colony.

The *phylastic* stage has already been alluded to. This is the earliest stage capable of fossilization. It represents the period from the first appearance of a hard exoskeleton to the completion of the protœcium. In the Bryozoa, as pointed out by Barrois,[1] the exotheca at first differs considerably in appearance and texture from the more compact investment of later stages. The buds of the next generation (primary buds) originate at or slightly before the close of this stage. The protœcium frequently resembles the later formed zoœcia of ancestral types (Nitsche,[26] Pergens[28]).

The *nepiastic* stage is taken to represent the period from the formation of the primary buds, *i. e.*, those buds which are given off by the protœcium, to the establishment of the definite budding habit of the colony. The researches of Nitsche,[26] Pergens,[28] and others, have shown that the early budding habit frequently differs considerably from the later or normal habit of the colony, and more nearly resembles that of ancestral types. This stage may be conveniently subdivided into ana-, meta- and paranepiastic substages. The first, or ana-stage, will include the protœcium and completed primary buds. The meta-stage marks the termination of encrusting growth in forms that produce erect zoaria. The initial circle of buds in *Fenestella* belongs to this stage. The para-stage comprises the transition from the latter to the neanastic stage.

Figs. 36–43 show the primary buds of several types of recent Bryozoa. It will be noticed that in every case the first formed buds are *lateral*, and that a median bud may or may not be present. It is also noteworthy that only one of these eight types has more than three primary buds. The *Cyphonautes*, fig. 38, has six, an altogether exceptional number.*

* The order of budding is indicated by the small Arabic numerals, and the generation of a given bud by the Roman numerals. 1, indicates the median bud; 2, the left lateral; and 3, the right lateral bud. In the case of buds of succeeding generations the position number of each preceding generation is affixed to each bud, so that its entire ancestry is thereby expressed. For example, in fig. 39, bud No. IV_{3232} is of the fourth generation and was derived from the right lateral primary bud through the left lateral of the second generation, and the right lateral of the third generation. Where the same position

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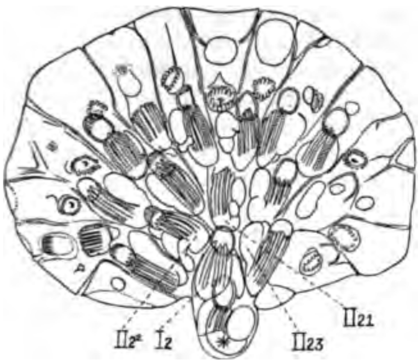

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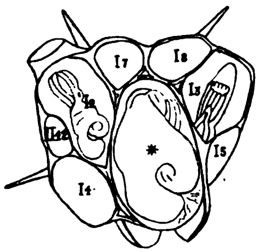

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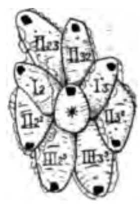

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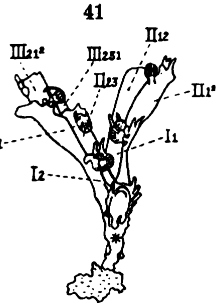

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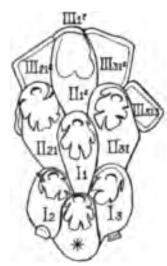

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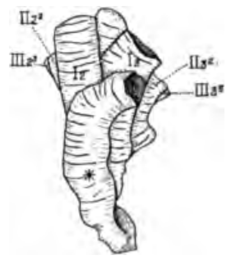


FIGURES 36–43.—Types of budding from the protœcium. (Figure 36, after Davenport; figures 37–43, after Barrois.) Protœcium marked by star. Order of budding indicated by Roman and Arabic numerals.

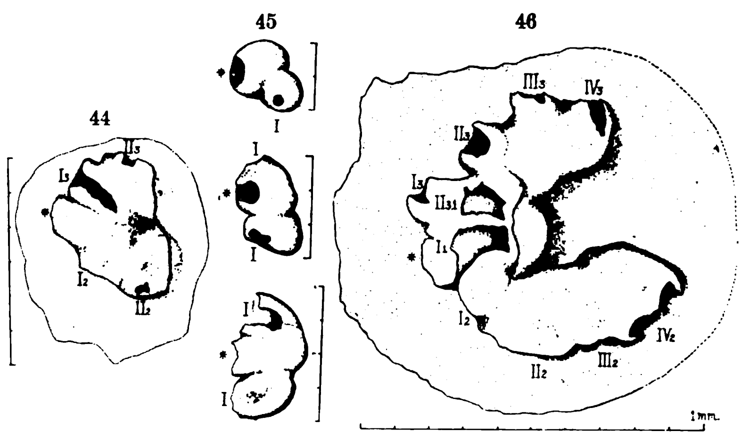
36. *Lepralia*; 37. *Alcyonidium*; 38. *Cyphonautes* (*Flustrella*); 39. *Schizoporella*; 40. *Microporella*; 41. *Bugula*; 42. *Membranipora*; 43. *Tubulipora*.

Figure 36 × 21; figure 37 × 35; figure 38 × 30; figure 39 × 30; figure 40 × 25; figure 41 × 10; figure 42 × 20; figure 43 × 20.

number is repeated consecutively an exponent is written to it; thus, in fig. 43, $III_3{}^3$ means III_{333}, *i. e.*, a bud of the third generation derived from the right lateral primary bud through the right lateral of the second generation. With slight modification this nomenclature would be equally applicable to the corals, or any other colonial type of organism.

In many cases, as in *Alcyonidium* (fig. 37), *Schizoporella* (fig. 39), *Lepralia* (fig. 36), and *Bugula* (fig. 41), one of the lateral primary buds is suppressed. Where but one of the lateral buds develops, it may be the right or left indifferently, as in *Alcyonidium* (Barrois[1]); or the right almost invariably, as in *Schizoporella*. In *Schizoporella* the left lateral is sometimes normally developed, but more often exists as a vestige or is totally lacking. Both lateral buds are, according to Barrois, never present together in *Alcyonidium*, but the indifferent position of the lateral bud indicates that the plan is fundamentally that of two lateral buds. In *Tubulipora*, according to Barrois' interpretation, I_3 (fig. 43) would be derived from I_2; but from the analogy of other Cyclostomata,* and from a careful study of Barrois' figures, the writer is disposed to consider I_2 and I_3 as in reality representing the two lateral buds. It will be seen later to what extent the development of two lateral buds from the protœcium prevails among all types of Ectoproctous Bryozoa. The ananepiastic stage is quite similar for all.

II. *Development of Fenestella.*



FIGURES 44–46.—Primary budding stages of *Fenestella coronis* from the Lower Helderberg (Shaly) limestones of Indian Ladder, New York.

45. Top figure, protœcium (*) and one lateral bud (I); middle figure, protœcium (*), one lateral bud and beginning of another (I, I); lower figure, protœcium (*) and two lateral buds (I, I); 44. Protœcium (*), two lateral buds (I_2, I_3) and two buds of the second generation (II_2 and II_3) arising from I_2 and I_3; 46. Protœcium (*) and buds of the 1st (I_1, I_2, I_3), 2d (II_2, II_3, II_{31}), 3d (III_2, III_3) and 4th generations (IV_2, IV_3).

All figures ×45.

* Harmer[11] has shown that two sister buds are thus derived from the protœcium in *Lichenopora*.

The *neanastic* stage begins with the assumption of the habit f budding that is to characterize the adult colony. In some ases (*Membranipora*, *Bugula*, *Alcyonidium*) this takes lace very early, the meta- and paranepiastic stages being reatly abbreviated or entirely lacking. In other cases (*Fenes-ella*) the adult habit of growth is frequently not suggested ntil as many as fifty or sixty buds have been produced. The eanastic stage terminates with the development of an adult olony.

The *ephebastic* and *gerontastic* stages refer, as in other rganisms, to fully adult and senile growths. The latter, espe-ially, is marked by the extinction of the earlier polypides of he colony and frequently by profuse deposits of secondary clerenchyma, as well as by other more or less extensive modifi-ations affecting the basal portion of the zoarium.

Phylastic Stage.

The youngest observed specimens of *Fenestella* consist of ninute globular bodies (fig. 45) of a diameter of about $0{\cdot}1^{mm}$, ound upon the zoaria of *Orthopora*, *Callopora*, and other Bryozoa of the Lower Helderberg (Shaly) limestone of Indian Ladder, N. Y. These minute bodies represent protœcia, and ave a definite aperture, but if the vestibule ever existed it as been broken away. That they are the protœcia of *Fenes-ella* is proved by their size relative to the zoœcia of adult col-nies of that genus, and by the very complete series (figs. 44–46) of connecting stages, as well as by the presence of similar odies on the bases of adult *Fenestella* colonies. The young-st individual figured (fig. 45, top) has already developed one ateral bud. The protœcium may frequently be recognized by ts large size and significant position in the circle of zoœcia ften to be seen on the base of well-preserved zoaria; it can e identified in transverse sections cutting the initial region of he colony, and especially in transverse serial sections of this egion. Its exact relation to the primary buds has been epeatedly demonstrated in serial sections of exceptionally pre-erved calcified material. The evidence bearing on this point vill be presented in a later paper.

Nepiastic Stages.

Ananepiastic Stage.—The initiation of this most interesting nd significant stage in *Fenestella* conforms to the general lan that obtains throughout the Ectoprocta. It consists in he formation of two lateral buds (figs. 44–46, I_2, I_3) and later f a median bud (fig. 46, I_1). This order of budding has been erified in numerous specimens of *Fenestella* from widely sep-rated horizons and localities. The lateral buds originate in

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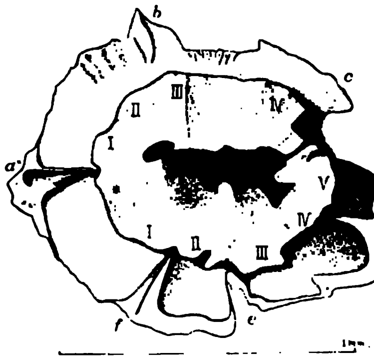

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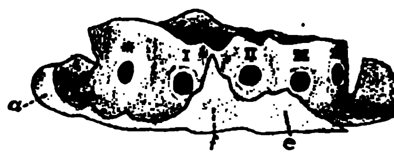

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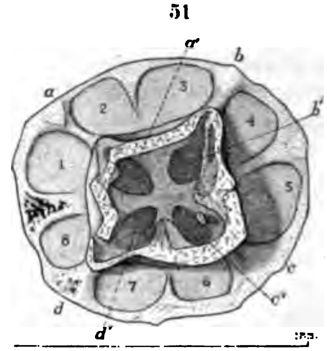

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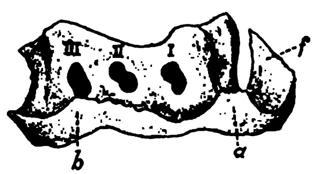

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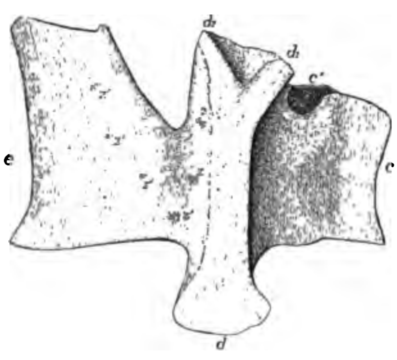

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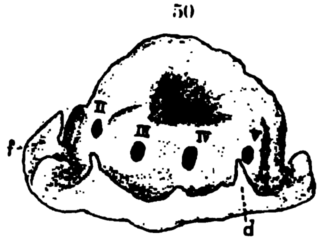

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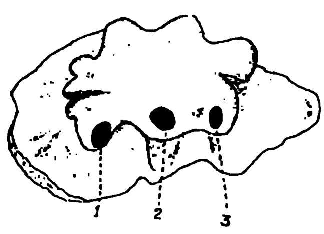

(For description see next page.)

uch a position as to give a backward trend or deflection to ubsequent budding, thereby giving rise to a hippocrepian (fig. 16) and later to a circular aggregation of buds (initial circle, netanepiastic stage, figs. 47–51) in which the protœcium occupies one end of a diameter, and the last formed bud of the ircle, the other. The median primary bud arises from the top f the protœcium considerably later than the lateral buds, *i. e.*, t about the time of completion of the initial circle. It forms he first individual of the second tier of buds, which lie symnetrically above the first tier.

Metanepiastic Stage.—In *Fenestella* this stage consists of he completed initial circle of zoœcia. It has been seen that he ananepiastic stage trespasses on it to the extent that the nedian bud does not arise till near the completion of this nitial circle. It constitutes an incrusting growth formed by udding in a horizontal plane, from which the adult colony rises by budding in vertical planes. Typically it consists of en zoœcia including the protœcium, but there is considerable ariation from this number even within the limits of a single pecies, so that initial circles of eight, twelve, or fourteen oœcia are not uncommon, while in a peculiarly accelerated orm found at Thedford, Ontario, only five of the typical umber develop. In the latter, circles containing ten zoœcia rise only after several generations of zoœcia have been proluced in vertical series. Such a zoarium is shown in fig. 55. The full discussion of this type of zoaria is deferred to a later ime.

In certain cases the initial circle is arrested at a hippocrepian r semicircular stage, either because the full number of zoœcia ails to develop, or because the trend of the budding produces oo great a divergence of the series of buds to the right and eft of the protœcium. From a metanepiasty of this type, a labellate zoarium will arise, unless subsequent growth is of such nature as to bring the lateral margins of the zoarium together.

DESCRIPTION OF FIGURES 47–54.

FIGURES 47–54.—Early stages in the development of *Fenestella* from the Hamilton limestone of Canandaigua Lake, N. Y. (47–50, 53–54), and the ower Helderberg limestone of Indian Ladder, N. Y. (51, 52).

47–50. Top and side views of a young *Fenestella* slightly older than the ndividual shown in fig. 46. Initial circle of zoœcia complete and walls of eighboring zoœcia fused more completely than in 46. This specimen has en (the typical number) zoœcia. The origin of the primary carinæ is shown t *a* to *f*. **51.** Another specimen at about the same stage as 47, primary arinæ *a* to *d*. Each of the pits, *a'* to *d'*, corresponds to two zoœcia; a faint eptum may be seen bisecting *d'*. The depressions in the basal plate (1 to 8) ark the position and limits of the exserted polypides. **52.** Stage somewhat lder than 51, showing first branching of primary carina (d_1, d_2) and three ers of zoœcia (*z, z, z, z, z, z*). Note the great size and prominence of the arinæ. **53, 54.** Another individual of the same age as 47.

All figures ×40.

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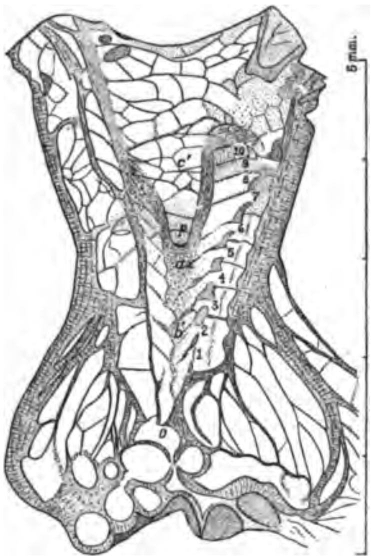

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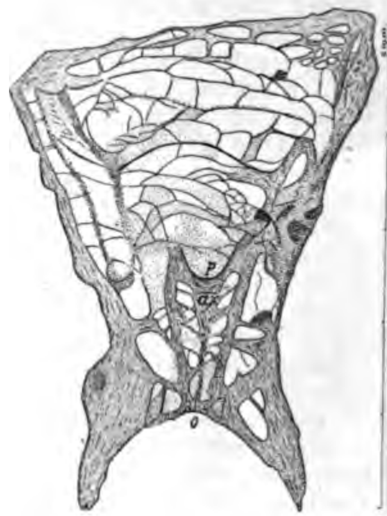

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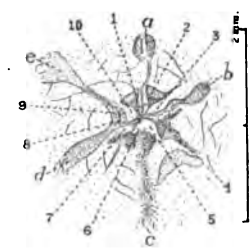

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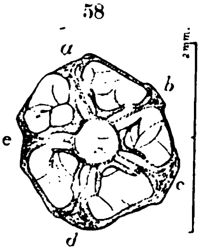

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rare instances the initially flabellate zoarium curves in the rerse sense and by fusion of the meeting edges forms an fundibular colony which has literally been turned inside out. ich zoarial modifications have given rise to the maximum of nfusion in the placing of species and genera of fenestrate 'yozoa, because in the adult colony lacking the base (as is nost invariably the case), the fundamental plan of budding entirely obscured.

The carinæ originate during the metanepiastic stage.

Paranepiastic Stage.—Successive tiers of zoœcia are added ove the initial circle until a cylindrical stem is formed which nstitutes the stalklike base of the adult cone. The paranepastic stage may be greatly abbreviated where the cone pands almost from the first circle of zoœcia, or it may be olonged to five or six tiers of zoœcia (fig. 55). If such a lindrical stalk is conceived of as slit longitudinally down the le diametrically opposite the protœcium and unrolled and flatned out, it will be seen that the protœcium lies at the base of vertical series of zoœcia from which lateral branches are ven off on either side. In other words, the budding follows avenport's law that the median bud continues the ancestral w. It is not certain, however, that any importance is to be tached to this law.

Near the close of the paranepiastic stage the axis of the arium thickens preparatory to the expansion of the cone. his is well shown in figs. 55 and 56 (longitudinal sections) id figs. 58 and 62 (transverse sections) of specimens from the amilton of Thedford, Ontario. The thickened axis (*ax*) is mposed of an outer wall continuous with the proper wall of e carinæ, and an inner dense deposit of punctate sclerenyma. The section shown in fig. 60 cuts just at the top of is thickened axis.

DESCRIPTION OF FIGURES 55–60.

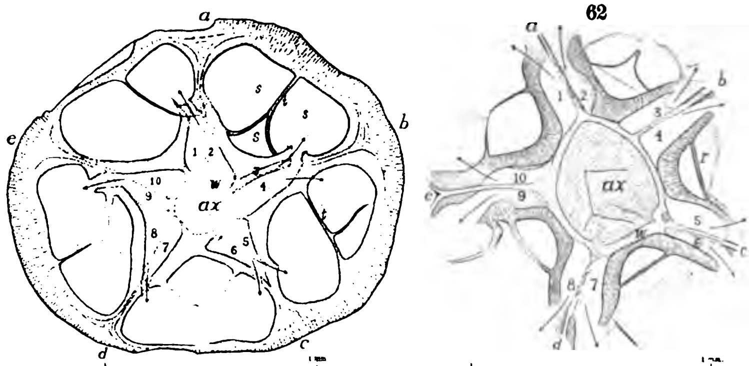
FIGURES 55–60.—Longitudinal and transverse sections of bases of *Fentella* from the Hamilton formation of Thedford, Ontario.

55. Section of a *Fenestella* base cutting exactly in the plane of the axis d of the zoœcial apertures to the right (1 to 10). The initial zoœcium (procium) is at *o*; the thickening of the axis (*ax*) commences at *b'*; the apex the cone of expansion of the colony is at *p*; the vesicular tissue (*c'*) ove *p* is of secondary origin, forming during the mature and senile life of e colony. Fig. 56 shows the thickening of the axis, and oblique direcon of the zoœcia, but does not cut through the zoœcial apertures. 57. ansverse section through the initial region of another individual (about in e plane of 1, fig. 55); *a–e*, primary carinæ; 1 to 10, primary row of œcia. 58. Transverse section through the thickened portion of the axis bout in the plane of *ax*, fig. 55) of another individual; *a–e*, primary rinæ (see also fig. 62). 59. Transverse section in the plane of *c'*, fig. , showing nine carinæ. 60. Transverse section in the plane of *p*, fig. , showing, in the lower portion of the figure, a carina just in process of ranching.

All figures × 13.

Morphology of the Carinæ.—The primary carinæ first make their appearance in the metanepiastic stage, and are intimately related to the basal plate (figs. 47–54). In fact the carina seems to originate as an upgrowth or fold of the basal plate. It is structurally double or more properly triple (figs. 57–62), consisting of a thin median plate or wall continuous with the axial wall (*w*) and coinciding with planes of division between adjacent zoœcia; and on either side an outer layer of dense, punctate sclerenchyma. This median or proper wall, as it approaches the axis, becomes extremely thin, and is therefore apt to be destroyed, a fact that will account for the hiatus between *d* and *f* and the stalk of the zoarium in figs. 48 and 49. In early stages the carinæ are discrete, except near their junction with the basal plate, where they coalesce with the upturned rim of the latter (figs. 47, 51); but in ephebastic and gerontastic stages the earlier formed zoœcia become entirely submerged in a copious deposit of secondary sclerenchyma, which bridges adjacent carinæ, and gives a perfectly smooth cylindrical aspect to the stalk of the colony (cf. figs. 52, 58 and 60).

61 62



FIGURES 61, 62.—Transverse sections of base of *Fenestella* from the Hamilton formation of Thedford, Ontario. 61. Transverse section in the plane of *b'*, fig. 55, showing the presence of five primary carinæ and ten zoœcia. The heavy external wall joining *a*, *b*, *c*, *d*, *e*, is of secondary origin. In early stages the carinæ *a*, *b*, *c*, *d*, *e*, are discrete. The axis, *ax*, has a well-defined wall, *w*, continuous with the primary axes of the carinæ. 62. Same section as fig. 58—axial portion showing axial wall, *w*, and its continuation as the axes or midribs of the carinæ; *a–e*, carinæ; 1–10, zoœcia.
Figure 61 × 28; figure 62 × 31.

The height of the carinæ, breadth of the basal plate, and position and extent of the secondary deposits are sharply defined by the limits of action of the exserted polypides. The circular or semicircular depressions frequently seen in the

basal plate opposite the aperture of each zoœcium indicate very clearly the radius of action of each corresponding polypide (figs. 47, 51, 53, 54). It will be seen at once that the carinæ, without interfering noticeably with the movements of the exserted polypides, afford a very efficient means of protection against the snipping off, by some obnoxious visitor, of the tentacles of the polypides. That the danger of such rude treatment is by no means imaginary is abundantly proved by the fact that recent Bryozoa are frequently found with their tentacles lost or in various stages of regeneration. The carinæ also function as strengthening structures, especially in the basal portion of the zoarium, and may, by secondary deposits during later growth stages of the colony, be greatly increased in height and breadth. The completed nepiastic stage, with its strong carinæ, is strikingly suggestive, both in external appearance and in sections, of a segment of *Arthroclema*. (Cf. the axial region of fig. 55 with fig. 83, left.)

Neanastic Stage.

This stage begins with the assumption of the conical habit of growth. A plane passing through the apex of the cone (*p*, figs. 55 and 56), therefore, separates the nepiastic from the neanastic region of the zoarium. Fig. 52 shows a *Fenestella* just entering upon the neanastic stage. The nepiastic stage in this individual comprises three tiers of zoœcia or thirty zoœcia in all, including the protœcium. The first branching of one of the primary carinæ is shown at d_1, d_2. Fig. 60 shows the same phenomenon in transverse section. Fig. 59 shows a transverse section cutting the neanastic region of a slightly smaller zoarium, at a somewhat higher level. The vesicular tissue occupying the apex of the cone is of altogether secondary origin. It is deposited mainly during the gerontastic stages.

It will be noticed that the zoœcia of *Fenestella* lie always on the outside of the expanding cone, *i. e.*, they face away from the axis of the zoarium. It is also evident that this habit of growth is impressed upon the zoarium from the very outset. In any case where the initial circle of zoœcia (metanepiasty) is completed, the resulting zoarium will be a cone with the zoœcia on its outer surface. Where, for any reason, the initial circle is incomplete or abnormal, the resulting zoarium will, as has been pointed out above, be flabellate, or produce a cone by modifications arising during the neanastic stage. Such abnormal cones may, by reversal of the normal curvature, bring the zoœcia on the inside. *This fact does not, however, modify the*

fundamental type, which is determined by the position and orientation of the primary buds. It may, therefore, be positively asserted that, ontogenetically considered, the zoœcia of Fenestella always lie on the outer surface of the cone.

It is now necessary to consider the question of the original definition of *Fenestella*. Several authors have recently restricted this genus to forms having the zoœcia on the *inner* surface of the cone, notwithstanding the fact that Lonsdale,'' in his original diagnosis of the genus, distinctly states that they lie always on the *outer* surface! It does not appear to the present writer that the fact that Lonsdale'' afterward redefined the genus so as to make it practically coterminous with the whole family of Fenestellidæ, as at present accepted, has anything to do with the question. In any subsequent restriction of the genus by other authors, the original sense of the original publisher of the genus should have been ascertained and followed as closely as possible. The first species mentioned by Lonsdale under the newly erected genus is *Fenestella Milleri*, named after Mr. Miller, who had already proposed the genus in manuscript. *F. Milleri* clearly and unmistakably has the zoœcia on the outer surface of the cone. There cannot be the slightest doubt that *F. Milleri* represents Lonsdale's original conception of the genus. In the face of this fact the claims of *Gorgonia antiqua* and *Fenestella plebeia*, which Mr. Shrubsole'' identifies with it, must be considered as worthless.

Ephebastic and Gerontastic Stages.

The detailed consideration of adult and senile stages of the zoarium of *Fenestella* raises certain points the discussion of which the writer prefers to postpone till a more complete survey of the specific representation of this and related genera can be undertaken. Enough has been determined, however, to make it certain that the founding of species upon slight variations occurring on small fragments of zoaria is an exceedingly questionable practice. The modifications of zoaria due to age may be profound. The writer has, for example, seen hundreds of specimens of most exceptionally well-preserved Lower Helderberg and Hamilton Bryozoa, in very many cases showing the entire zoarium. These specimens make it perfectly certain that many of the species that have been enumerated from these formations, and founded on fragments of zoaria, are spurious. They may often enough represent merely different growth stages of a single individual. *The only reliable criterion of a species is the entire zoarium.*

III. *Development of Unitrypa.*

The genus *Unitrypa* is characterized by the presence of transverse bars or scalæ, connecting adjacent carinæ at intervals corresponding approximately to the spacing of the zoœcia along the branches of the zoarium. Otherwise it conforms closely in habit and structure to *Fenestella.* The development of this genus reveals certain altogether remarkable features in connection with the origin of the scalæ, or carinal bars.

Nepiastic Stage.

The nepiastic colony of *Unitrypa* is an object of exquisite beauty, consisting of a delicate translucent cup wherein is lodged the pentamerously branching trunk or stalk of the zoarium, with its slender arching carinæ and diamond-shaped incipient scalæ (figs. 63–68). The presence of this perfectly formed cup is altogether unique, and its intimate relation to the carinal superstructure is beyond question.

The earliest stages (ana- and metanepiastic) of *Unitrypa* are indistinguishable from corresponding stages of *Fenestella.* Very early, however, the margin of the basal plate begins to curve upward into a shallow cup or saucer. At this stage the carinæ have not yet made their appearance, or are represented merely by slight ridges down the outer edges of the incipient branches (fig. 69). At a corresponding stage of *Fenestella* the carinæ are strongly marked (fig. 47). The margin of the basal plate continues to grow upward until a deep cup is produced surrounding the branching stalk of the zoarium (figs. 63–68). Near the termination of this stage each branch (a'–e') becomes united by a thin vertical plate (the carina) to the margin of the cup. This plate or carina sends out lateral processes about midway from the outer wall of the branch to the margin of the cup, at a point where the edge of the carina is abruptly deflected downward toward the wall of the cup (figs. 64, 65 and 69). The plane of these lateral processes is about parallel to a plane tangent to the wall of the cup where the carina joins it. In later stages these diamond-shaped processes are seen to coalesce midway between adjacent carinæ, so as to form transverse bars or scalæ. The processes are therefore the rudiments of scalæ (fig. 70). The margin of the cup is frequently scalloped in a manner conforming to the curvature of the basal margins of these incipient scalæ.

The primary branches originate at about the third or fourth tier of zoœcia (fig. 69). The basal plate is indented opposite the aperture of each zoœcium of the initial circle. The neanastic and later stages of *Unitrypa* are quite similar to corresponding stages of *Fenestella.* The zoœcia are carried up the

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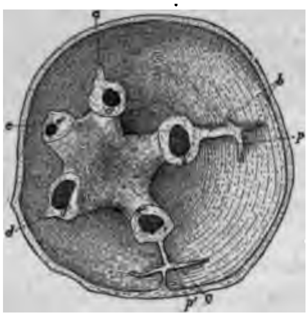

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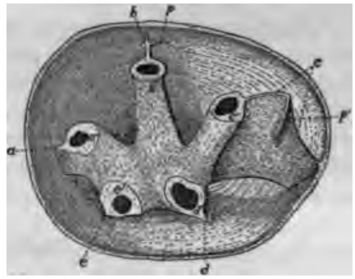

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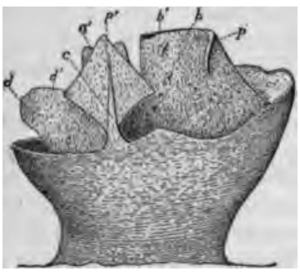

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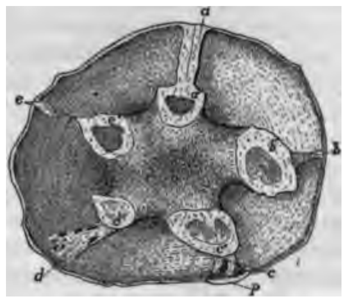

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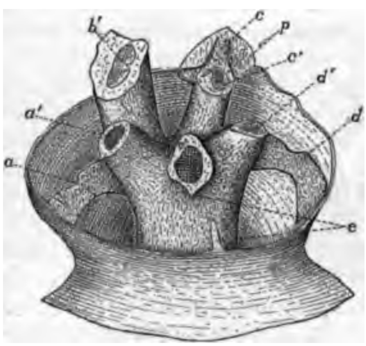

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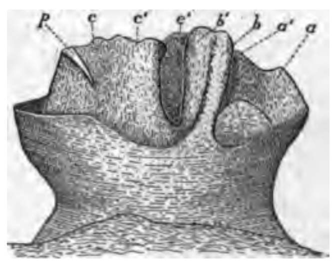

Figures 63–68.—Early stages of *Unitrypa* from the Lower Helderberg (Shaly) limestone of Indian Ladder, N. Y.

63–65. Top, oblique, and profile views of an individual showing five primary branches (a' to e'), five carinæ (a to e), and transverse plates (p, p'). Fig. 64 shows that the carina does not reach the bottom of the cup. In fig. 65 the plate p' is seen to be of diamond shape, extending laterally from the carina, while the parallelism between the slope of the plates and the wall of the cup is well shown at p. 66–68. Another individual showing similar features. The hiatus between the carinæ and the bottom of the cup is beautifully shown at a and d, fig. 67, and one of the transverse plates at p, fig. 67, and p, fig. 68.

All figures × 26.

branches in double rows in precisely the same way as in the latter genus. The presence of scalæ is the only distinguishing character. In *Unitrypa* as in *Fenestella* the zoœcia are always on the exterior surface of the cone.

Homology of Parts in Unitrypa and Fenestella.—The carinæ are undoubtedly homologous in the two genera. They do not, however, reach the bottom of the cup in *Unitrypa*, or

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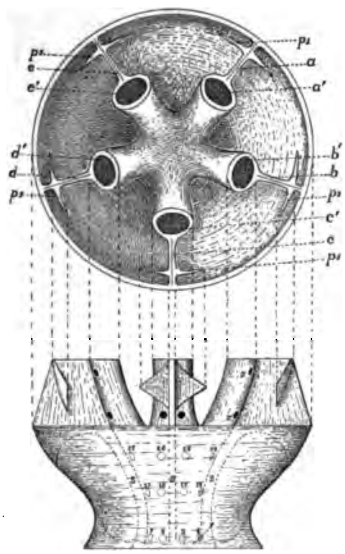

FIGURE 69.—Plan and elevation (semi-diagrammatic) of young *Unitrypa* of the stage shown in figs. 63–68. *a*–*e*, primary carinæ: *a'*–*e'*, primary branches; p_1–p_6, transverse plates (scalæ). The zoœcia are numbered to correspond to fig. 61. Three rows are present below the margin of the cup and two above. The probable orientation of the exserted polypide is shown by the arrow at 4. The basal plate is indented opposite each zoœcium as in the young of *Fenestella*. × 26.

at least if they did their inner portion was too delicate to be preserved (figs. 64, 67, 68). The cup is in appearance unlike anything to be found at a corresponding stage in *Fenestella*. Nevertheless there are strong reasons for considering it as homologous, in the main, with the basal plate of the latter. The rim of the cup may, however, represent one or more of the earlier scalæ fused with the margin of the basal plate. The scalloping of the rim suggests this latter interpretation. The cup might very well overspread the entire outer surface of the zoarium were it not for the necessity of adequate circulation of water over the zoœcia. This condition is approximated in some types (*Isotrypa*, *Semicoscinium*).

It is not unlikely that the form and position of the carinæ and carinal superstructures (scalæ, etc.) is very largely determined by the same necessity which, in the writer's opinion, has, in the case of the Brachiopoda and Pelecypoda, given rise to shell plication, namely, that of admitting water and excluding enemies. The protection afforded by such structures as the scalæ of *Unitrypa* and the still more elaborate superstructure of *Hemitrypa** is very complete. Of course any such

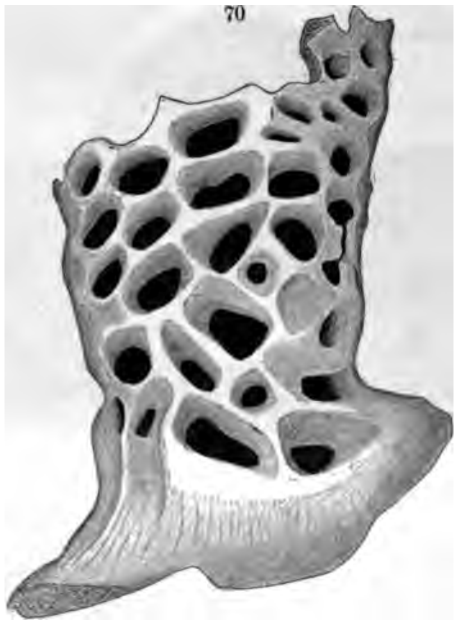

FIGURE 70.—Base of a neanastic *Unitrypa*, showing obliquity of transverse plates (scalæ), and thickened and modified representative of initial cup. × 20.

advantage is gained at the corresponding disadvantage of less perfect circulation of water over the zoœcia than is the case where they are unprotected.

IV. *Development of Polypora.*

Nepiastic Stages.

Ananepiastic Stage.—The earliest observed stage of *Polypora* consists of the protœcium and five encircling zoœcia (figs. 71–77). Even at this early stage the primary branches, seven

* Thin sections indicate that the early nepiastic stages of *Hemitrypa* are identical with those of *Fenestella*.

in number, are defined (figs. 72, 73, *a–g*). In *Polypora* the distal margin of the zoœcia is elevated, so that by careful inspection of the initial region of a young colony, the initial (central) zoœcium can be readily identified. In transverse sections, also, of the base of adult colonies the primary zoœcia can be easily determined (fig. 77). In the section shown herewith, the protœcium, because of its lower position, and more intimate contact with the substratum, had been broken open from beneath through its thin basal plate, and infilled with the iron-stained material of the matrix, thus making it a very conspicuous object in the transparent section. The primary zoœcia are arranged very symmetrically about the protœcium,—one in front, two to the right, and two to the left. There can be no doubt that the individual in front and the anterior pair of lateral individuals represent the median and lateral buds. Whether the posterior pair of lateral individuals represents another set of lateral primary buds or was derived from the anterior lateral buds cannot at present be definitely settled. Certain silicified specimens of *Polypora*, showing the initial region at the base of the zoarium, make it practically certain that the zoœcia in question were derived from the anterior lateral buds. In *Retepora phœnicea*, which has exactly the same arrangement of zoœcia about the protœcium as *Polypora*, these posterior buds are undoubtedly derived from the anterior laterals.* The buds marked II in fig. 77 are manifestly not derived from the protœcium.

If the posterior pair of laterally placed buds is not primary, *i. e.*, derived from the protœcium, the stage represented in fig. 77 is to be regarded as metanepiastic, since the branching and ascent of the colony from the surface of support commence with the formation of the next circle of buds. Fig. 73 shows an individual just entering the neanastic stage. The meta- and para-stages are therefore greatly abbreviated in *Polypora*.

Comparison with Fenestella.

It requires no very minute inspection of the nepiastic stages of *Fenestella* and *Polypora* (cf. figs. 77 and 57; 76 and 46; 73 and 47; 74 and 52) to reveal a profound difference in the development of the two genera. The median bud of *Polypora* arises in front of the protœcium, instead of on top as in *Fenestella*. The protœcium of *Polypora* is surrounded by subsequent zoœcia and therefore comes to occupy a central position. In *Fenestella* the protœcium remains one of a more or less complete circle of zoœcia, and is in no sense central in position. The zoœcial apertures face upward and toward the axis of the zoarium in

* The budding order has been determined by the writer, in *Retepora phœnicea*, from St. Vincent's Gulf, S. Australia. Specimens showing the protœcium alone, and the protœcium and three primary buds, are now in the Yale University Museum, and will be described in a later paper.

***Polypora*, but outward and away from the axis in *Fenestella*. In normally developed *Fenestella* cones, therefore, the zoœcia**

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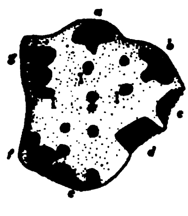

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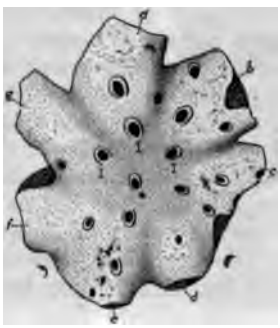

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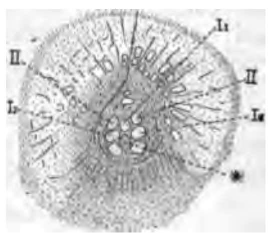


FIGURES 71-77.—Nepiastic stages of *Polypora*.* 71-76. Young individuals showing the protœcium (*) and primary buds (I, I, I) and the beginning of the primary branches (*a* to *g*). Fig. 74 (paranepiastic stage) shows the latter feature very perfectly. 77. Section through the base of an individual from Thedford, Ontario, showing protœcium (*) surrounded by seven zoœcia, five of which are in contact with it. I_1, I_2, and I_3 must have arisen from the protœcium.

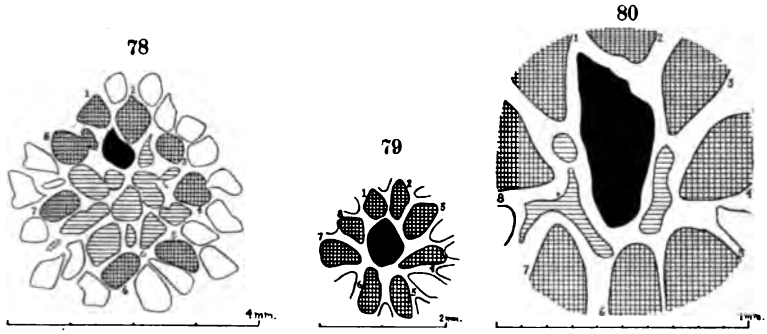
Figures 71-74 × 26; figures 75-76 × 30; figure 77 × 13.

are always on the outer surface of the cone, while in normally developed Polypora cones the zoœcia are always on the inner surface of the cone. The type is determined by the position and orientation of the primary buds.

* Compare with these figures, Ulrich's figures of *Sphragiopora*. Geol. Sur. Illinois, viii, pl. lxv, figs. 6, 6a.

In *Polypora* as in *Fenestella* a partial or asymmetrical development of the metanepiasty may give rise to flabellate forms, and by reversal of curvature an occasional cone may arise in either genus, with the zooecia on the surface opposite the usual one, *i. e.*, the zoarium may turn inside out. Such variations in no way modify the fundamental type.

Notwithstanding, therefore, the insistence with which authors have proclaimed the intimate connection between *Polypora* and *Fenestella*, such supposed close relationship is only another case of morphological equivalence. Waagen and Pichl's[48] erection of subfamilies for the reception of these respective types is more than justified by unmistakable evi-



FIGURES 78–80.—Initial zooecia of *Paleschara* from the Lower Helderberg (Shaly) limestone of Indian Ladder, N. Y. Black = protoecium; cross-hatched (1 to 8) = primary buds; cross-lined = interstitial buds of a later generation. 1, 2, and 3 are in immediate contact with the protoecium.

79–80. Lower surface of the colony; 78. Upper surface. The primary zooecia diverge rapidly in passing to the upper surface.

Figures 78, 79 × 8; figure 80 × 32.*

dence, of the existence of which those authors were, however, entirely ignorant. *Fenestella* and *Polypora*, as now constituted, comprise a heterogeneous assortment of forms, partly belonging to outside genera and partly entitled to remain where they are. When the correct generic relationships of these forms are determined, the proper arrangement of genera will be to place all forms having the nepiastic stages as in *Fenestella* in the family *Fenestellidæ*, and all forms having the nepiastic stages as in *Polypora* in the family *Polyporidæ*. *Thamniscus* will not belong to either of these families. The position of the other genera now referred to the family Fenestellidæ as at present constituted, can be determined by an investigation of their development. The writer does not venture an opinion beyond the limits of the types already so

* The numbers 1, 2, 3, etc., in these figures are not intended to indicate the order of budding.

studied. Certain persistently flabellate forms should, however, be placed in appropriate genera, as suggested by Simpson."

The number of rows of zoœcia, which has been considered the chief differential character between *Polypora* and *Fenestella*, is of altogether subordinate value. Carinæ do not occur in *Polypora*. It is believed that there are physiological as well as developmental reasons for this.

V. *Development of Paleschara.*

Two specimens of *Paleschara* from the silicified Lower Helderberg material show the initial region of the zoarium (figs. 78–80). The protœcium is slightly larger than the other zoœcia and is closely surrounded by eight buds. Whether these all originated from the protœcium cannot be determined; from the analogy of other Bryozoa the belief would be justified that they did not. It is significant that their number and arrangement are the same as in the recent genus *Microporella*. The zoœcia numbered 1, 2, and 3 in the figures are in more intimate contact with the protœcium than the others (4–8) and may represent the median and lateral buds. From the analogy of *Microporella*, however, the median bud should be lacking; and 3 and 8 should represent the lateral buds from which 1 and 2 were produced.

VI. *Conclusions.*

In general all Bryozoa, both recent and fossil, thus far studied, conform to a fundamental plan of primary budding. This consists in the development from the protœcium of one or two lateral buds and frequently of a median bud which arises somewhat later.* Any apparent departure from this plan is found on closer inspection to conform to it. *Fenestella*, *Unitrypa*, *Polypora*, and probably *Paleschara* conform strictly to this plan of budding.

In *Fenestella* the primary buds arise in such a position and are so orientated as to cause the apertures of all subsequent zoœcia to face *away from* the axis of the zoarium. In *Polypora* the primary buds arise in such a position, and are so orientated as to cause the apertures of all subsequent zoœcia to face *toward* the axis of the zoarium. This difference is taxonomically of *family* value. In certain cases the full number of buds may be lacking in the metanepiastic stage, or, when present, they may have an unusual arrangement, and give rise, for either reason, to asymmetrically developed or flabellate colonies. Such

* This fact will afford a solution to the systematic position of the Trepostomata, since the budding from the *prototheka* (πρῶτος + θήκη) of corals follows an entirely different law.

colonies arise in both the Fenestellidæ and Polyporidæ, and may be produced with such persistence as to give rise to flabellate genera. In other cases they occur sporadically, and undoubtedly in its phylogenesis this peculiarity first occurred only in occasional individuals.

The carinæ of *Fenestella* originate as septal upgrowths of the basal plate, coinciding with planes of division between adjacent zoœcia. They are manifestly protective and strengthening structures.

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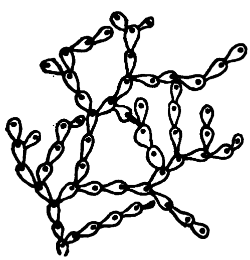

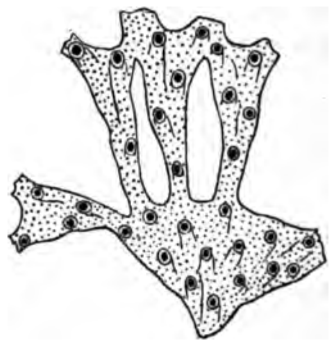

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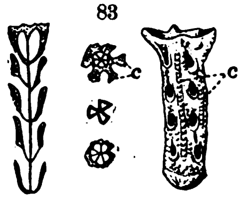

FIGURE 81.—*Stomatopora* from the Trenton of Minnesota, showing the propagation of the colony by simple linear budding, or by formation of two lateral buds. × 6.

FIGURE 82.—*Proboscina* from the Trenton of Minnesota, showing incipient coalescence of branches. × 12.

FIGURE 83.—*Arthroclema* from the Trenton of Minnesota, with transverse and axial sections of another species. Compare with axial portion of fig. 55. Sections × 13; other figures × 9.

Unitrypa and *Hemitrypa* conform in their ana- and metanepiastic stages to *Fenestella*, but differ from the latter in the production, during the paranepiastic stage, of a peculiar cup, surrounding and embracing the basal stalk of the zoarium. This cup represents the upgrowth of the margin of the basal plate, and the fusion therewith of one or more series of primary scalæ, through acceleration of growth of the latter structures. In their ontogenesis the scalæ are intimately related to the

carinæ, and represent a further elaboration of the latter for protective purposes.

It is still too early to attempt a phylogenetic classification of the Ectoprocta. The present studies will, it is believed, indicate the direction in which such a classification must be sought. The budding of all colonial organisms, after the primary stages, is apt to be very irregular, since the growing colony as it increases in size is more and more compelled to accommodate itself to the limitations of space and food supply. Only the nepiastic stages, therefore, have any phylogenetic value or any classificatory value higher than generic. The uniformity of the nepiastic stage in Bryozoa (Ectoprocta) suggests a common ancestor, which propagated by means of lateral buds, forming bifurcating series.* *Stomatopora* presents this type of budding, rarely producing a median bud in addition to the two lateral ones. Where there is a linear series of buds, the writer is disposed to consider the individuals of such a series as representing unpaired lateral buds (fig. 81). Some specimens of *Stomatopora* very forcibly suggest this interpretation.

Through *Proboscina* (fig. 82) and related forms, the genetic line from linear and anastomosing zoaria like *Stomatopora* to true incrusting forms is very complete; and the development of *Fenestella* seems to show how cylindrical and infundibular zoaria may be derived from incrusting zoaria. The ancestors of the Ectoprocta (Cyclostomata, Cryptostomata, Chilostomata) may be sought, therefore, in the direction of *Stomatopora*-like types.

Further than supplying a method, the present studies have done little to clear up the mystery of the Trepostomata. In the writer's opinion, they indicate a rather more remote relationship between this and other orders of Bryozoa than certain authors have held. The Trepostomata are a very ancient type, but they probably do not stand in a linear relation to any other order of Bryozoa.†

The author's studies strengthen the view advanced by Ulrich[45] that the Cryptostomata are the Paleozoic representatives of the Chilostomata. *Polypora* and *Retepora* are precisely alike in their early budding stages.

November, 1903.

* Davenport[7] holds a somewhat different view.

† *Phylloporina* is a composite genus in no way ancestral to *Fenestella*. *P. corticosa* belongs to the Trepostomata.

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ART. VI. — *Effects on Rare Earth Oxides produced by Radium-Barium Compounds and on the Production of Permanently Luminous Preparations by Mixing the Latter with Powdered Minerals;* by CHARLES BASKERVILLE and GEORGE F. KUNZ.

THE following rare earth oxides in powdered condition were mixed with radium-barium chloride of 240 activity. The mixture was shaken in test tubes and carefully observed in the dark to note any luminosity. None was observed with any one of the oxides. The following oxides were used: thorium, zirconium, titanium dioxides; zinc, cerium, lanthanum, yttrium, ytterbium, erbium, a mixture of the last three, praeseodidymium, neodidymium, lanthanum, gadolinium, samarium and uranium oxides.* They were not examined with a microscope, although a magnifying glass was used.

Berthelot† compared certain specific chemical reactions caused by light and an electric current with those provoked by radium. He noted that the work is tedious on account of the small quantities of radium to be used and the necessity for working in glass envelopes, which absorb part of the rays and in certain cases probably the most efficient portion. M. and Mme. Curie noted that various chemical effects produced by radiations from radium were similar to light. Becquerel‡ extended the examination with a sealed glass tube enveloped in aluminum foil. Glew§ gives a random list of substances which fluoresce, and some which do not, when submitted to the action of radium bromide within a glass container and surrounded by black paper. Crookes' spinthariscope‖ is an instrument for showing the luminescent effect produced upon a Sidot's blende screen by exposed radium salts. Elster and Geitel¶ independently observed the luminosity produced by the bombardment of radium "electrons" and showed the difference between phosphorescence produced by emanation and that produced by illumination. We have not, however, learned of any experiments where pulverized materials, mineral and chemical preparations, have been mixed directly with radium-barium compounds of different composition and activities in this manner.

We** have mixed pulverized chlorophane, willemite, zinc oxide (made by the French process), zinc sulphide, and

* The sources of these oxides are given in a previous paper. This Journal, Dec., 1903, p. 465.

† Compt. Rend., cxxxiii, 659.

‡ Compt. Rend., cxxxiii, 709 (1901).

§ Nature, July 2, p. 3, 1903.

‖ Chem. News, lxxxvii, 241.

¶ Physik. Zeitschr., iv, 15, 439.

** Trans. N. Y. Acad. Sci., Oct. 6, 1903.

kunzite,* with radium-barium chloride (240 activity) and carbonate (100 and 40 activities). All gave good luminosity.

It may be recalled that in a previous communication it was stated that of the oxides mentioned above when submitted to the action of ultra-violet light, only two of them became phosphorescent, namely, zirconium and thorium dioxides.

Further, it should be noted that one of these oxides is not radio-active, namely, zirconium dioxide, while thorium dioxide is; also that uranium oxide, which is radio-active, does not respond to the ultra-violet light. *Is it possible that we have a common constituent in zirconium and thorium that differs from the others and still is different from the constituent which makes uranium responsive?*

It has been frequently noted and is well known that chlorophane is extremely sensitive to ethereal or mechanical stresses, giving evidence of such sensitiveness by luminosity. We have learned, as will be published later in full, that chlorophane contains yttrium and ytterbium. Neither of these oxides responds either to the ultra-violet light or the radium; hence we cannot attribute the sensitiveness of chlorophane to their presence. *Is it not possible that we have here, as well as in willemite and the other zinc compounds mentioned, a new substance, perhaps elementary, which acts as a radium foil, as it were?*

We propose to carry on further the investigation of these matters.

* This contains zinc as will appear shortly in the completed analysis by one of us (B) and Davis.

Art. VII.—*On the Numbers of Nuclei produced by Shaking Different Liquids and Allied Results*; by C. Barus.

1. In my report on the nucleus,* I showed that the number produced in a given mode of comminution was least in pure water, greater in dilute organic solutions and still greater in dilute inorganic solutions, all of the same strength. Results were also given for other solvents than water, in particular for benzol; but I was unable to reduce the data to the same scale as for aqueous solvents, as the data needed for the reductions were not at hand. I have since found that the method of Wilson and Thomson† lends itself to benzol and have, therefore, computed the data over again as shown in Table I.

The pressure reduction used to effect the condensations was throughout $\delta p = 16^{cm}$. Hence at about 20° the adiabatic fall of temperature in case of a benzol-air medium should be as far as $-10{\cdot}2°$, the rise of temperature thereafter (due to condensed liquid) to 11·3°, and consequently the liquid benzol precipitated per cubic centimeter $m = 30{\cdot}4 \times 10^{-6}$ grams. The goniometer factor was $a = {\cdot}0031 = d\,s$, being the product of the diameter d of the fog particle and the apertures of the corona. Hence the number of nuclei per cubic centimeter is finally $n = 1{\cdot}95\,(10\,s)^3$, all the coronas in question being normal, excessively intense and brilliant.

This may be compared with water. The corresponding temperature reduction of the water air medium is to $-7{\cdot}6°$, the rise of temperature due to the ensuing condensation as far as 9·5°, so that $m = 4{\cdot}5 \times 10^{-6}$ grams per cub. cm., almost 7 times smaller than the corresponding datum for benzol. When the same goniometer as above is used, therefore, $n = {\cdot}29\,(10\,s)^3$.

Table I.—Number of nuclei produced by identically shaking solutions of one per cent concentrations.

Solution, etc.	Nuclei per cm³ of air.	Solutes.
Pure water	130	--------
Organic bodies in water	630	sucrose, glucose, glycerin, urea, tartaric acid
Inorganic salts in water	1260	Na_2SO_4 $CaCl_2$ $Ca2NO_3$ K_2SO_4 $FeCl_3$ Al_3NO_3 alum $NaCl$ $Fe3NO_3$ Na_3PO_4 HCl H_4NNO_3
Naphthalene in benzol.	3500	
Paraffine in benzol	5000	

* Smithsonian Contrib., No. 1373, chap. v, 1893.
† Phil. Mag. (5), xlvi, p. 538, 1898.

The curious result thus appears that the number of nuclei produced by a definite amount of shaking is least for water, about 5 times greater for dilute organic solutions in water, about 10 times greater for dilute inorganic solutions in water, and about 30 to 40 times greater for dilute solutions of non-conductors like naphthalene and paraffine in benzol. It is difficult to even conjecture a reason for this behavior.

2. *Coronas in general.*—The coronas in benzol for the same pressure differences as above are all normal even if nucleation from sulphur, phosphorus, etc., is introduced. From the slow diffusion of the vapor they soon become distorted during successive exhaustions unless the vessel is shaken between each. It is interesting to show, however, that in spite of the normal coronas, the high initial nucleation is fully accounted for. To do this I shall select a series of observations for coronas in benzol vapor at random (l. c., p. 56). Sulphur nuclei were used and the vessel shaken between observations. The table gives the results.

TABLE II.—Coronas in benzol vapor, shaken between observations. $\delta p = 18^{cm}$; $n = 6m/\pi d^3$; $m = 88 \times 10^{-6} g$ per cm³; $d = \cdot 00144/s$.

Exhaustion No.	$d \times 10^3$ observed. cm.	$d \times 10^3$ computed. cm.	$n \times 10^{-3}$ computed.
0	Fog without coronas	·2	6,800
1	" " "	·3	3,200
2	" " "	·4	1,400
3	" " "	·5	610
4	" " "	·6	270
5	·8	·8	120
6	1·0	1·1	52
7	1·3	1·4	23
8	1·8	1·8	10
9	2·6	2·4	4·4
10	3·7	3·2	1·9
11	4·2	4·2	·85

Computed exponentially the initial nucleation would run up into the millions. The observations are not, however, in keeping with such a locus and conform more closely to $1 = d(1/d_0 - z\sigma/a)$ or $s = s_0 - \sigma z$ and $ds = a$. For present purposes this is near enough. I shall, therefore, lay off the aperture s as a linear function of the number of the exhaustion z, for which the observations show per unit of z, in case of sulphur nuclei, $\delta s = \cdot 28$ and in case of punk nuclei $\delta s = \cdot 19$. The initial aperture computed herefrom as the mean of six series in each of which the nucleation was introduced independently, are for sulphur, $s_0 = 3{\cdot}4$ and for punk $s_0 = 2{\cdot}2$. Hence $n_0 = 840{,}000$ in the former case and $n_0 = 230{,}000$ in the latter.

Since the pressure ratio was in each case 1·36, the nuclei in the influx air passing over burning sulphur or glowing punk must have been 3·8 times more numerous. Thus there were nearly 3 million sulphur nuclei and nearly 900,000 punk nuclei per cubic centimeter in the laden air currents entering the condensation chamber.

I shall show elsewhere that the equation applicable to the present experiments is

$$n_z = n_Z 10^{(z-Z)\log y} \prod_{Z}^{z-1} (1 - S/s^2),$$

where n_Z is the initial nucleation, y the volume ratio on exhaustion, z the number of the exhaustion and S an appropriate subsidence constant. The function Π is a product of the terms

$$(1 - S/s^2_Z)\,(1 - S/s^2_{Z+1})\;.\;.\;.\;(1 - S/s^2_{z-1})$$

so that Z is the number of the exhaustion in which the first corona is seen and $\Pi = 1$. When the particles are as large as is the case for benzol the subsidence function is of prevailing importance and masks the exponential function, as all the observations for benzol show. I have carried this method out for water vapor, obtaining consistent results throughout. The present observations for benzol are scarcely systematic enough to make worth while to compute S, and the experiments should be such in which the diffusion and homogeneity of vapor is ensured by continued rotation of the vessel rather than by shaking. But there can be no doubt that with proper precautions in this respect, the number of nuclei furnished per cubic centimeter by any given nucleator can be determined with benzol vapor, as the coronas are all normal even for large values of nucleation, with certainty.

3. *Axial colors.*—It is because of the relatively great number of relatively large particles in case of benzol and similar hydrocarbon vapors, that the axial colors are seen and may be traced into much higher orders than is the case with water vapor. The yellows, browns, etc., of the first order may be easily obtained with the steam jet though they can not be produced in the condensation chamber by any means whatever. The subsequent violets, blues, etc., however, are here distinctly seen as far as the orange-red of the second order, after which the admixture of white light makes recognition of color more and more difficult. With hydrocarbon liquids like gasolene, benzine, etc., the axial colors are seen much farther along the series even through a short column, and they are intense in the drum. The difficulty in observation encountered is due to the slow diffusion and consequent absence of homogeneous vapor.

I hope, however, by keeping the drum in rotation around the axis of vision as already suggested to counteract this discrepancy and correspondingly to prolong the series.

4. *Carbon disulphide.*—The vapor of this reagent is another in which coarse normal coronas usually appear. The endeavor to produce the higher coronas with sulphur, punk or air nuclei fails if the pressure differences are of the same order as those used for water. Particles of the fog are usually about $d = {\cdot}001^{cm}$ in diameter for strong nucleation, and the dense coronas produced on shaking showed diameters of the order of $d = {\cdot}0015$ under the given conditions of exhaustion. Relatively large coronas were obtained with nuclei which apparently rise from this reagent spontaneously. Thus after about 2 hours $d = {\cdot}002$, after 6 to 15 hours $d = {\cdot}0012^{cm}$ was observed. The fact that the coronas increase in size in the lapse of time suggests other explanation than the slow diffusion of vapor or the difficulty in keeping it uniformly saturated when successive exhaustions are made. For in this case coronas would decrease and the size of the particles increase, whereas the reverse is observed.

The computation of the number of nuclei per cubic centimeter for carbon disulphide is more precarious in view of the high vapor pressures and the deficiency of data applying throughout the range of temperature involved. For the case of a pressure decrement of $\delta p = 18^{cm}$ from 76^{cm}, and at 20°, the adiabatic fall of temperature would be as far as —34°, the rise therafter due to condensed liquid as far as 5°. This implies 53×10^{-6} grams of fog particles per cubic centimeter, whence with the above goniometer the number of nuclei per cubic centimeter would be $n = 34\ (10\ s)^3 = {\cdot}10/(10\ d)^3$.

The coronas obtained by spontaneous nucleation thus correspond to $n = 13{,}000$ after three hours and $n = 50{,}000$ after 6 hours or more. Finally punk nuclei after two or three exhaustions with shaking were still present to the number of $n = 75{,}000$ per cubic centimeter.

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SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *Titrations with Potassium Iodate.* — A new application of iodates in volumetric analysis has been devised by LAUNCELOT W. ANDREWS. This depends upon the fact that in the presence of a great excess of hydrochloric acid the reaction

$$HIO_3 + 2HI + 3HCl = 3ICl + 3H_2O$$

takes place, and upon the fact that while iodine itself colors an immiscible solvent, such as chloroform or carbon tetrachloride, the iodine monochloride imparts no color to the solvent, although it gives a bright yellow color to the hydrochloric acid solution. Therefore, the iodine in an iodide may be accurately determined by placing the solution of the iodide in a glass-stoppered bottle, adding about an equal volume of concentrated hydrochloric acid and about 5^{cc} of chloroform, and then running in a standard solution of potassium iodate until, after shaking, the chloroform becomes colorless. The end-reaction is exceedingly sharp, while ferric and cupric salts, oxalic acid and small quantities of bromides do not interfere with the operation. The process may be used also for the determination of free iodine, in which case the following reaction takes place:

$$HIO_3 + 4I + 5HCl = 5ICl + 3H_2O.$$

It may be used in determining chromates, if a titrated solution of potassium iodide is at hand. In this case an excess of the iodide is added to the chromate solution, and the excess is determined by the addition of iodate solution. Chlorates can be determined in a similar manner, but here an amount of pure fuming hydrochloric acid at least one-third greater than the volume of the solution should be added, and the bottle should be allowed to stand for 15 minutes before titrating with potassium iodate. Solutions of arsenious acid or chloride can be titrated in the same way as iodides. Here, however, the amount of actual hydrochloric acid in the liquid must be kept between 15 and 25 per cent. The determination of antimony is precisely like that of arsenic. Since copper as a cupric salt does not interfere, it is possible to determine arsenious acid in Paris green without a preliminary separation. Ferrous salts can be titrated in exactly the same way as iodides, but here the end reaction appears to lack sharpness, although test analyses with ammoninm-ferrous sulphate gave very satisfactory results.

The method promises to be an important addition to our volumetric processes, since nearly all of the analyses usually made by Bunsen's method of distillation can be made by it more easily, and also because it is applicable to some important special cases. —*Jour. Amer. Chem. Soc.*, xxv, 756. H. L. W.

2. *The Oxidation of Platinum.* — It has been generally supposed, up to the present time, that metallic platinum is incapable of being oxidized by the action of air or oxygen, and that platinum-black consists of a mechanical mixture of pure platinum with condensed oxygen. The latter view does not appear to be in accordance with general chemical principles, but it has held its place in chemical literature, probably on account of the high authority of Liebig and Döbereiner who advocated it. LOTHAR WÖHLER has recently described an elaborate research in regard to the behavior of platinum with oxygen, and he has shown conclusively that this metal is susceptible to oxidation. The presence of an oxide in platinum-black was shown by the fact that iodine was set free by it from potassium iodide. It was found that platinum-black, by being heated for a long time in contact with oxygen, took up the latter to the extent of 1·92 per cent at 100° and 2·35 per cent at 300°, although the limit of oxidation was not reached. It was found that oxidized platinum-black was soluble in dilute hydrochloric acid to the extent of from 10 to 18 per cent of its platinum, and it was found that precipitated platinous hydroxide was entirely analogous in many reactions to the oxidized platinum-black. Moreover, grey platinum sponge, by long heating in oxygen at 420–450°, was converted to the extent of 40 per cent into a black powder which was found to be platinous oxide, although the limit of oxidation was not reached, and even the oxidation of platinum foil was found to be possible, as was shown by its increase in weight and very marked change in color.

The results of this investigation are important, since they furnish a satisfactory explanation of much of the chemical behavior of finely divided platinum.—*Berichte*, xxxvi, 3475.

H. L. W.

3. *The Production of High Vacua for Distillation.* — Chemical distillations under diminished pressure are commonly made by use of the water-jet pump, but the nearest approach to a vacuum obtainable with this apparatus is from 8 to 15^{mm} pressure, according to the temperature of the water. For lower pressures mercury pumps or other air-pumps may be used, but as these are not always available, ERNST ERDMANN has devised a process for the purpose which depends upon the low vapor tension of carbon dioxide at the temperature of liquid air. The apparatus to be used for distillation is first exhausted by means of the water pump to 30 or 35^{mm}, then, by means of a suitable connection provided with a glass stop-cock, carbon dioxide produced in a Kipp generator and dried with sulphuric acid and calcium chloride is admitted until the apparatus is filled with it. The apparatus is then exhausted as before, and the filling with carbon dioxide and exhaustion are repeated three times, when a small bulb connected with the apparatus is immersed in liquid air. The pressure then sinks within a minute to less than $0{\cdot}5^{mm}$, usually to $0{\cdot}2$ or $0{\cdot}3^{mm}$. If the filling with carbon dioxide and exhaustion have been repeated a fourth time the pressure is still lower, and it has been

ound that where the use of rubber stoppers and tubing is avoided t is possible to produce a cathodic vacuum by this method. The ,rticle under review states that the liquid air, a supply of which s necessary for this process, can now be purchased in London for ess than 50 pf. per kg, and that it is becoming more easily ›btainable in Germany.—*Berichte*, xxxvi, 3456. H. L. W.

4. *A Method of Crystallizing difficultly Soluble Substances.*—\. DE SHULTEN employs for the purpose under consideration a ›rocess which consists in mixing, very slowly, hot, dilute solutions ›f two substances which give the substance sought by double lecomposition.

For example, a solution of 10^g of $BaCl_2 \cdot 2H_2O$ in 3 liters of vater, to which are added 300^{cc} of concentrated HCl, is heated in ı flask on a water-bath, and into this are allowed to fall drop by lrop, at the rate of one or two drops per minute, 2 liters of a olution of sulphuric acid containing 2^g of the acid per liter. \fter 24 hours the first crystals of barite appear at the bottom of he flask, and they increase gradually without the formation of ıny precipitate. At the end of a month 8 or 9^g of barite are 'ormed. By the same process alumina is deposited in the form ›f hydrargillite. The author has obtained several other artificial ninerals in this way, including celestite, anglesite, haidingerite, :rythrite, annabergite, and scheelite.—*Comptes Rendus*, cxxxvi, 664. H. L. W.

5. *Fractional Distillation;* by SYDNEY YOUNG. 12mo, pp. !84. London, 1903 (Macmillan and Co.).—This book has been pre›ared with the hope that the solution of the difficulties which so ›ften occur in carrying out a fractional distillation may be renlered easier, and that the value and economy of highly efficient ,till-heads in laboratory work may come to be more widely recogıized than is generally the case at present. It is an excellent reatise on the subject, and chemists will find it interesting as vell as useful. H. L. W.

6. *Elektro-Metallurgie;* von Dr. W. BORCHERS, Dritte Auflage, Zweite Abtheilung. 8vo, pp. 289 to 578. Leipsic, 1903 (S. Hirzel). —The first part of this book was noticed in this Journal about a 'ear ago. The second part now under consideration completes he work. It treats of silver, gold, zinc, cadmium, mercury, in, lead, bismuth, antimony, vanadium, chromium, molybdenum, ungsten, uranium, manganese and iron, as well as of carbides and ilicides. The work is a very important and valuable contribuion to the theoretical and practical knowledge of this rapidlyleveloping branch of industry. H. L. W.

7. *A New Form of Galvanometer.*—One hardly expects to ind in the description of new galvanometers a radical departure rom old types, yet the instrument devised by W. EINTHOVEN of he physiological laboratory of the University of Leyden justiies the title of a new galvanometer. It consists of a silvered |uartz fiber of extremely small diameter, $2 \cdot 1\,\mu$ diameter, which is tretched between the poles of a magnet. When the magnetic

field is excited the filament moves out of the field and the movement is read by a microscope. The author was led to devise the instrument from a consideration of the elements which enter into the law for the normal sensitiveness of a galvanometer. It was seen that a mirror, however small, limited the possible sensitiveness. The quartz fiber was stretched between the poles of a magnet of $12 \cdot 5^{cm}$ height, which enclosed a field of from 20,000 to 23,000 c. g. s. The poles are bored in order to light the fiber and also to allow the use of a microscope. By means of a slit at right angles to the axis of this boring, it was possible to photograph the excursions of the fiber under varying currents. Photographs of these oscillations are given. The microscope employed magnified 660 times. The period of swing is very short; in a case mentioned by the author only 0·004 sec. The sensitiveness is from 100 to 200 times that of the most sensitive instrument (Panze galvanometer of Rubens) hitherto constructed. The instrument is not affected by jars and vibrations to which other galvanometers are subject, and would seem to be of great use in the detection of minute currents, or rapidly varying currents, which are studied in physiological investigations.—*Ann. der Physik*, No. 13, 1903, pp. 1059–1071. J. T.

8. *The Magnetic Properties of Systems of Corpuscles describing Circular Orbits.*—This paper by Prof. J. J. THOMSON is mathematical and not experimental. The problems discussed are:

(1) The magnetic field due to a number of negatively electrified corpuscles situated at equal intervals round the circumference of a circle and rotating in one plane with uniform velocity round its center.

(2) The effect of an external magnetic field on the motion and periods of vibration of such a system.

These problems are met with when we attempt to develop the theory that the atoms of the chemical elements are built up of large numbers of negatively electrified corpuscles revolving around the center of a sphere filled with uniform positive electrification. The mathematical analysis shows that when the velocity of the particle is small compared with V, the velocity of light, the rate at which energy radiates, diminishes very rapidly as the number of particles increases. It is also shown that a body whose atoms contain systems of rotating particles is not necessarily magnetic, and that we cannot explain the magnetic or diamagnetic properties of bodies by the supposition that the atoms consist of charged particles describing closed periodic orbits under the action of a force proportional to the distance from a fixed point. We cannot explain the magnetic properties of bodies by means of charged particles describing, without dissipation of energy, closed orbits. When there is dissipation of energy the particles may possess magnetic properties.

In discussing this point, Thomson remarks that if the energy of projection were derived from the internal energy of the atom, there would be a continual transference of energy from the atom

the surrounding systems; this would tend to raise the temrature of the system. He proposes to test the question whether : temperature in the middle of a mass of a magnetic substance e iron, whose surface is kept at a constant temperature, differs m the temperature inside a mass of a non-magnetic substance e brass, whose surface is kept at the same temperature.—*Phil. ag.*, Dec., 1903, pp. 673–693. J. T.

9. *Laboratory Physics.* A Student's Manual for Colleges and ientific Schools; by D. C. MILLER. Pp. xv + 403. New York, 03 (Ginn & Co.).—This is a book to be highly commended. The periments given with the object of teaching manipulation are not) trivial as it is too often the case, and those given to illustrate demonstrate principles are not too intricate or difficult for the ide of students for which the book is written. The introductory narks on observations, errors, corrections, probable error, signifiit figures, graphical methods, etc., are admirably done. The book cept within a reasonable compass by means of giving the theory the experiments for the most part in references. In order for s method to work satisfactorily, an adequate quiz system must company the laboratory work. This is in line with the author's a to make the laboratory an intimate and not a separate part the general instruction in physics. He advises that more than f of the whole time spent on physics be given to lectures and itations. This idea of the unity of the subject is one which : prevalence of the elective system in this country has tended obscure. The separation between experimental and theoretical ysics is intellectually vicious, though, unfortunately, often made our colleges. Hence it is doubly a pleasure to welcome a book it aims to aid in the teaching in the laboratory of that part of oretical physics which can advantageously be so taught; and t to teach "Experimental Physics" as if it had a separate stence.

The book closes with an adequate set of tables of physical connts, etc., though why such a useless table of trigonometric funcns should be included is hard to see. L. P. W.

10. *Physical Laboratory Manual for Secondary Schools;* by E. COLEMAN. Pp. 234. New York, 1903 (American Book Co.). This appears to be an excellent example of this class of manual. venty-seven exercises, of which about two thirds are quantitae, are outlined. Of these some forty or fifty are suggested as vering the usual ground of the laboratory courses of secondary ools, thus leaving considerable margin of choice in experiments the teacher. The directions, as far as examined, seem to be ar and concise. The attention paid to the computation of perntage errors in data and result is especially to be commended. e main adverse criticism to be made on the book is one that plies to the majority of its class, namely, that the teaching of antitative relations by means of equations is practically ignored. hy is mathematical reasoning, one of the most fundamental l important methods of reasoning known to physics, entirely

slighted in books like this? Such omissions cannot fail to foster in the minds of the student the false notion that in some way experimental physics has a separate existence from theoretical physics. L. P. W.

11. *Elements of Electromagnetic Theory*; by S. J. BARNETT, New York, 1903 (The Macmillan Company).—This is a systematic treatment of the elements of electromagnetic theory with its simpler non-technical applications. The English attitude of making the concepts, with which one has to deal, real physical entities by the use of "tubes" and mechanical ethers is emphasized. We note that the author uses the rational units of Heaviside. The large number of figures enliven the text and the numerous references to original memoirs and advanced treatises materially add to the value of the work for the really serious student. The closing chapters on convection and displacement currents, flux of electro-magnetic energy, and electric waves puts the student into a position to read with profit the modern theories of light and of disturbances in the ether in general. The work has long been needed and is a welcome addition to our literature on mathematical physics. E. B. W.

II. GEOLOGY AND MINERALOGY.

1. *United States Geological Survey*, C. D. WALCOTT, Director. —The following publications have recently been received:

FOLIO NO. 95. Columbia, Tenn.; by C. WILLARD HAYES and EDWARD O. ULRICH. The Columbia quadrangle is located on the western margin of the Central Basin of Tennessee and shows the topography, structure and sedimentary record of the Cincinnati arch on the western flank of which it is located. The sediments are Silurian and Carboniferous separated by a thin bed of Chattanooga shale (Devonian). Commercially this region is of great interest because of the presence of rock phosphates. Ten phosphate horizons are recognized in Ordovician and Devonian strata. The Ordovician phosphatic limestones were deposited in very shallow water and made almost wholly from phosphatic shells of mollusks, "which seem to have flourished almost to the exclusion of the more characteristic elements of the Ordovician fauna." The brown phosphate of commerce is the result of the leaching to which these rocks have been and are now subjected. The Devonian phosphate rocks are partly due to animals then living but largely to the residual mantle overlying the weathered Ordovician limestones.

The addition of a faunal chart and of a sheet illustrating the fossil fauna which appears in this folio is to be commended.

FOLIO NO. 96, Olivet, South Dakota; by J. E. TODD. The Olivet quadrangle includes part of the James River Valley and its features are those of very subdued glacial topography. With the exception of a very few small outcrops of Benton and Colorado (Cretaceous), the entire region is mantled by drift of the

Visconsin stage. Two systems of well-marked moraines are hown. As a study of simple glaciation and of water conditions his folio occupies a unique place.

BULLETIN No. 217. Notes on the Geology of Southwestern daho and Southeastern Oregon; by ISRAEL C. RUSSELL. 80 pp., 8 pls., 2 figs.

Taken in connection with Bulletin No. 199 and Water Supply Paper No. 78, the publication of Professor Russell's recent work ives a fairly complete account of the general geological relaions of the interesting Idaho-Oregon arid region. Malheur Lake (a water body 135 square miles in area and less than 10 ft. leep!) is not a remnant of a larger lake but is caused by a lava lam. The volcanic phenomena of this region is particularly nteresting. Details of structure, of character of flows, cones, ombs, are described and illustrated. Many of the bombs were ot formed by rotation in air. Besides the recent volcanics, Teriary lake beds and lavas occur in this area.

WATER SUPPLY AND IRRIGATION PAPER No. 85. Report on Progress of Stream Measurements for the Calendar year 1902; y F. H. NEWELL. Part IV. Interior Basin, Pacific Coast and Hudson Bay Drainage. 239 pp., 2 maps.

No. 86. Storage Reservoirs on Stony Creek, California; by BURT COLE. 60 pp., 15 pls., 38 figs.

2. *New York State Museum*, F. J. H. MERRILL, Director, has ecently issued the following publications:

BULLETIN No. 66. Index to Publications of the New York State Natural History Survey and the New York State Museum; y MARY ELLIS; pp. 239–653. An Index has been made to the ublications of the New York Survey and related scientific rganizations covering the years 1837–1902. The arrangement ives: a list of publications; author index; subject index; index o descriptions of fossils. This bulletin renders readily accessible he scientific data distributed in an apparently haphazard way hrough various New York reports.

MAP OF THE STATE OF NEW YORK showing surface configuation and watershed. This map, drawn on a scale of 12 miles to he inch, is especially valuable for the physiographer and for use n schools.

3. *Geology of Worcester, Mass.*; by JOSEPH H. PERRY and B. K. EMERSON. 159 pp., fully illustrated. Published by the Worcester Natural History Society.—Mr. Perry has for several ears been assisting Prof. Emerson in mapping the metamorphic ocks of Worcester County under the direction of the U. S. Geoogical Survey and has now published part of the results of this vork. Because of the nature of the region, mineralogical and etrographical descriptions constitute the greater part of the ook. Geologists will be interested in the descriptions and excelent illustrations of *Lepidodendron acuminatum*, the only fossil et found over a wide area in Massachusetts and Connecticut. The occurrence of this fossil shows the Worcester phyllite to be

of Carboniferous age and gives a starting point in geological chronology for the variable metamorphics east of the Connecticut Valley Triassic.

4. *The Paleontology and Stratigraphy of the Marine Pliocene and Pleistocene of San Pedro, California;* by RALPH ARNOLD. Mem. California Acad. Sci., vol. iii, 420 pp., 37 pls., June, 1903.—Mr. Arnold has produced an admirable monograph on the later fossil faunas of the California coast. The investigation was carried on under the supervision of Professor J. P. Smith of Leland Stanford University and is based upon the study of six large collections of the fossils discussed, 408 species of which are cited. The chief sections studied are at San Diego, San Pedro, Ventura, Santa Barbara and Lake Merced, and represent strata from 150 to 5350 feet in thickness.

The formations recognized are the Merced series, chiefly Pliocene, and the lower and upper San Pedro of Pleistocene age.

The Pliocene species are 87 in all, of which 63·1 per cent are now living at San Pedro; 18·5 per cent of the whole fauna are species living only north of San Pedro, and no species only south of that point. Of the 247 species from the lower San Pedro beds (Pleistocene), 64 per cent are living at San Pedro, 17·4 per cent only north and 3·2 per cent only south of that point.

Of the 252 species from the typical beds of the upper San Pedro (Pleistocene) 68·2 per cent are living, 6·1 per cent live only north and 14·2 per cent only south of San Pedro. From these facts the author concludes "that during the latter part of the Pliocene epoch the climate was much colder on the coast of Southern California than at the present time," p. 65; "that climatic conditions were changing from boreal toward tropical during the time of the deposition of the lower San Pedro series, but that boreal conditions still preponderated," p. 66. "The evidence offered by the upper San Pedro faunas leads to the conclusion that semitropical conditions prevailed during the deposition of this formation. The similarity of the fauna of these beds with that now living at San Pedro and the adjacent coast, makes it probable that the conditions, although more tropical than those of the present time, were not extremely tropical," p. 67.

A comparison of the Japanese with the Californian coast species, fossil and living, shows that great similarity exists between the late Tertiary and Pleistocene marine invertebrate fauna of Japan and that of the western coast of the United States; and the living faunas of the Japanese and West American coasts, though having many species in common, are not so closely related as are the upper Tertiary and Pleistocene faunas of the same region. H. S. W.

5. *Postglacial and Interglacial (?) Changes of Level at Cape Ann, Massachusetts;* by R. S. TARR. *With a Note on the Elevated Beaches;* by J. B. WOODWORTH. Bull. Mus. Comp. Zool. xlii, pp. 181–196, 13 pls.—Evidences of several kinds indicate that Cape Ann has been depressed to a level at least 40 to

) feet lower than the present. Beds of crumpled and faulted clays ₇erlaid by till and underlaid by gravels lie 25–30 feet above ean sea level and "there is little reason to doubt their interlacial age." Professor Woodworth finds evidences of strong ave action as high as 80 feet above the sea and concludes that ıarine action rather than glacial lake waters was concerned in ıe beach making.

6. *Latest and Lowest Pre-Iroquois Channels between Syracuse nd Rome, New York*; by H. L. FAIRCHILD. 21st Report New 'ork State Geologist, pp. 233–247, pls. 7–31.—The level waterlaned stretches utilized by the New York Central R. R. from yracuse to Rome and by the Erie Canal between Syracuse and 'anastota, were formed by rivers between the ice front and the igh ground on the south. The description and elaborate illustraon of these channels will be appreciated by teachers of geology specially.

7. *Contributions to the Tertiary Fauna of Florida, etc.;* by V. H. DALL. Part VI, pp. xi, 1219–1654, with plates xxviii–lx. 'hiladelphia, October, 1903.—This volume, appearing as vol. III, 'art VI of the Transactions of the Wagner Free Institute of cience of Philadelphia, forms the concluding portions of Mr. Dall's reat work on the Tertiary Fauna of Florida, repeatedly noticed ı this Journal. The author and the scientific public are to be like congratulated upon the successful completion of so importnt a labor and no small measure of thanks are due to the Wagner nstitute for its liberal support.

8. *Spinel Twins of Pyrite;* by WM. NICOL. (Communicated.) –Some time since, the writer found among a number of brilliant yrite crystals from French Creek, Pa., bought from Ward's cientific establishment at Rochester, two small ones which were vidently "spinel twins." In size the crystals were about 2^{mm} in iameter. They were found embedded in calcite and associated 'ith byssolite. In both cases the two twinned individuals were qually developed octahedrons showing the usual distortion, viz: attening parallel to the twinning plane. The faces when bserved on the Goldschmidt two-circle goniometer gave signal eflections with fairly good measurements, which showed withut doubt that the requirements of the spinel law were complied 'ith. In a later number of this Journal the details of the obserations will be communicated. As far as I can ascertain, the pinel law, by far the most common twinning law in the regular ystem, has not yet been observed in the case of pyrite, therecore it may be of interest to know that its existence has been roved beyond doubt.

9. *Ramosite not a Mineral;* by LEA McI. LUQUER. (Comıunicated.)—The doubtful mineral Ramosite occurring in pebles in alluvium from San Luis Potosi, Mexico, originally described y Perry in the Transactions of the American Institute of Mining ngineers in 1884 (vol. xii, 628), has been carefully reëxamined 'ith the following results.

Sections were obtained with great difficulty on account of the extreme hardness and brittleness, but proved the material to be greenish by transmitted light, non-pleochroic and isotropic and gave no indication of crystalline structure. Irregular fracture lines were common, sometimes approaching in appearances cleavages, and many minute shot-like grains of an iron-stained decomposed mineral were noticed.

The region in which the material occurs is volcanic, and the very marked vesicular structure and conchoidal fracture would indicate a volcanic scoria. The hardness from 8–9 is unusual, but basic scorias from the Sandwich Islands and elsewhere have shown a hardness from 6–7, greater than that of ordinary obsidian. The recorded analysis, for which no great accuracy is claimed, shows:

SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	MnO_2
46·32	13·00	9·19	17·74	13·13	trace = 99·38,

corresponding rather closely to formula $R_2O_3.4RO.5SiO_2$. The material qualitatively resembles garnet, but quantitatively differs widely; thus removing the possibility of it being a kind of garnet (as suggested by Dana).

The analysis of a tachylyte from Gethurms, Germany, by Lemberg,* shows:

SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	K_2O	N_2O	Loss
45·73	12·46	20·15	8·67	3·59	4·11	5·74	0·12 = 100·57,

as low in SiO_2 as the supposed Ramosite.

The evidence, therefore, shows the material to be *not a mineral*, but a basic scoria of unusual hardness and composition.

Department of Mineralogy,
Columbia University, N. Y., Nov. 4, 1903.

10. *List of New York Mineral Localities;* by H. P. WHITLOCK. Bulletin 70, Mineralogy 3, New York State Museum, F. J. H. Merrill, Director. Pp. 108, Albany, 1903.—This Bulletin will be found of much value by workers in mineralogy. It gives a carefully edited list of the species which have been found at various points in the state. The places are arranged under the separate counties, and the tables indicate the method of occurrence, the mineralogical association of the specimens, etc. In addition to the general introduction, a bibliography of two hundred and thirty-one numbers is given, to which references are made in the tables.

III. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *International Catalogue of Scientific Literature.*—The history and plan of the International Catalogue of Scientific Literature have been already given in this Journal (v. xiv, 317, 1902), and some of the volumes issued have been noticed (v. xv, 490, 1902). It is gratifying to be able to record the further progress

* Zeitschr., d.d. Geol., Gesell., xxxv, 570.

of this important enterprise, and the publication of an additional series of volumes of the first annual issue, that is for the year 1901. These include the following: D, CHEMISTRY, Part II, pp. 671; G, MINERALOGY, including Petrology and Crystallography, pp. 208; J, GEOGRAPHY, pp. 268; H, GEOLOGY, pp. 220; K, PALÆONTOLOGY, pp. 170; L, GENERAL BIOLOGY, pp. 144; P, PHYSICAL ANTHROPOLOGY, pp. 224; O, HUMAN ANATOMY, pp. 212; Q, PHYSIOLOGY, including Experimental Physiology, Pharmacology and Experimental Pathology, Part II, pp. 664. There is also a volume of 312 pages given to a List of Journals.

It is to be regretted that thus far no Government aid has been obtained for this great work, and hence its prosecution would have been rendered impossible in this country had it not been taken up by the Smithsonian Institution. At first only limited means were at its disposal, but beginning with July 1, 1903, a larger sum of money is devoted to it, increasing materially the force of workers. This will make it possible to carry on the work more promptly, and to fill up what omissions have occurred from January, 1901, to the present time. It is stated that this country leads in the number of subscribers, the total being ninety-six, equivalent to seventy complete sets, for which the yearly subscription is eighty-five dollars. It is highly to be desired that this relatively good showing should be much increased, as the enterprise is one of very great importance to workers in science and should have general support, particularly from the libraries.

2. *National Academy of Sciences.* — The following is a list of the papers presented at the recent meeting of the National Academy in Chicago (vol. xvi, 475).

T. C. CHAMBERLIN: Preliminary report on the Agassiz data relative to underground temperatures at the Calumet and Hecla mine.

C. E. DUTTON: The velocities of earthquake vibrations and their significance.

A. P. MATHEWS: The relation between solution tension and physiological action of the elements.

S. W. WILLISTON: On the distribution and the classification of the Plesiosaurs.

C. O. WHITMAN: The evolution of the wing-bars in pigeons.

CHAS. B. DAVENPORT: Evolution without mutation.

J. MCK. CATTELL: The measurement of scientific merit.

J. STIEGLITZ: Stereoisomeric nitrogen compounds.

CHARLES BASKERVILLE: On the recent investigations of the rare earths in the laboratory of the University of North Carolina.

E. E. BARNARD: Some peculiarities of comets' tails, and their probable explanation.

EDWIN B. FROST: Stars of the Orion class.

GEORGE E. HALE: On the nature of the solar flocculi.

GEO. C. COMSTOCK: The relation of stellar magnitude to stellar distances.

A. A. MICHELSON: Spectra of imperfect gratings.

STEPHEN MOULTON BABCOCK: The relations of weight and energy.

C. S. SLICHTER: The propagation of ground water waves.

WILLIAM H. BREWER: Biographical memoir of Sereno Watson.

3. *Astronomical Observatory of Harvard College*, EDWARD C. PICKERING, Director.—Recent publications from the Harvard Observatory include the following: Annals volume XLVI, Part I,

Observations with the Meridian Photometer during the years 1899–1902 by Solon I. Bailey. Volume XLVIII, Part V, Distribution of Stars; No. VI, Meridian Circle Observations of Eros and Comparison Stars; VII, Meridian Circle Observations of Nova Persei No. 2 and Comparison Stars; VIII, Intensity of Atmospheric Lines in the Solar Spectrum. Volume LI, A Photographic Atlas of the Moon by William H. Pickering. Also Circular No. 72, Intensity of Spectral Lines and No. 73, Opposition of Eros (433) in 1905.

The Photographic Atlas of the Moon, by Professor W. H. Pickering, is a notable work, giving, as it does, the first complete representation of this kind. The work was carried on at the Observatory at Mandeville, Jamaica, beginning in 1900. The telescope employed, constructed especially for the purpose, had a 12-inch objective (30^{cms}) and a photographic focus of 135 ft. 4 inches (4125^{cms}) so that a scale of 5 seconds to 1^{mm} was obtained. The length of focus required that the tube should be fixed and the objective viewed in the movable mirror. The results are given in a series of eighty beautiful plates, each of the sixteen portions of the surface being represented for five periods between sunrise and sunset, thus exhibiting the changes in appearance due to differences in lighting. One point of interest brought out is the variation observed at different times due to varying amounts of snow and frost in certain of the craters. Variation attributed to patches of vegetation was also observed within some of the craters. For the discussion of this and other matters of interest reference must be made to the original work.

4. *Beiträge zur chemischen Physiologie*, herausgegeben von F. Hofmeister. IV Band, 1–8 Heft., 1903. Braunschweig (Vieweg und Sohn).—The student of the chemistry of the proteids will continue to find a large number of the contributions in the *Beiträge* devoted to this department of physiological research. Special reference may be made here to papers by Gamgee and his coworkers on the optical activity of various albuminous compounds. Several of the latter are found to be markedly dextrorotatory, whereas the simple proteids are known to be lævorotatory. Digestive processes and enzymes receive attention in several papers; and two sulphur compounds, taurin and cystin, which possess considerable physiological interest, are made the subject of investigations reported from Hofmeister's laboratory. In addition to these there are papers on the precipitins; on crotin and ricin; and several communications on the lymphatic tissues by Bang, in addition to briefer notes on various experimental topics. L. B. M.

Obituary.

Herbert Spencer, one of the deepest thinkers of his time, whose philosophy has had a profound influence upon the intellectual men of all nations, died on December 8 at the age of eighty-three years.

THE

AMERICAN JOURNAL OF SCIENCE

[FOURTH SERIES.]

ART. VIII.—*On the Properties of a Radio-active Gas found in the Soil and Water near New Haven*; by H. A. BUMSTEAD and L. P. WHEELER.

IN the October number of this Journal, the writers published a brief note concerning a radio-active gas which had been found in the surface water near New Haven, in the course of some experiments which had been undertaken at the request of Professor J. J. Thomson. It was stated that the gas obtained from water had the same properties as that which was drawn from a few feet below the surface of the ground; and that both these gases, so far as the experiments had gone at that time, seemed to be identical with the gaseous emanation from radium discovered by Dorn. The purpose of the following investigation was a more careful and direct comparison of these "natural" radio-active gases with the radium emanation, in order to find out whether they contained a small proportion of some other active constituent.

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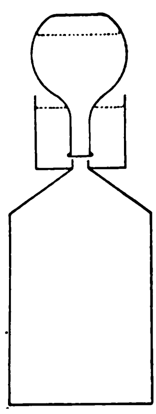

As in Professor Thomson's experiments, the gas was obtained from the water by boiling and, as it was, at best, rather feebly radio-active, it was desirable to prevent its dilution with air as much as possible. The method finally used is sufficiently indicated in fig. 1, and proved to be very convenient. It was suggested by Professor W. G. Mixter, to whom we are also indebted for several other valuable suggestions and for many kindnesses. The earlier tests of the gas were made by means

of a gold-leaf electroscope of C. T. R. Wilson's pattern, in which the leaf is supported by means of a sulphur bead from a rod kept charged to a potential at least as high as that of the leaf; so that any leak of electricity from the leaf must be through the gas and not over the support. A number of control experiments showed that the observed activity was not due to the vessels or drying tubes used, nor to the city supply pipes through which the water reached the laboratory; and the fact that water, once boiled, did not recover to any appreciable extent its power to give off a radio-active gas when left to stand, either stoppered or unstoppered, for two weeks showed that the presence of the gas was not due to contact with the air, nor to a dissolved, or suspended, radio-active solid. The latter conclusion was strengthened by our inability to find any evidence of radio-activity in the solid residue left on evaporating the water. As rain water does not contain a radio-active gas (although it does contain an active solid residue), the only hypothesis which seemed to be left to account for the presence of the gas in this surface water was that the water had come in contact with the gas in its passage through the ground and had dissolved some of it. Accordingly a piece of gas-pipe was driven about 1·5 meters into the earth and its top connected by a rubber tube to a flask filled with water; on allowing the water to run out, the flask became filled with the gas from under ground which was then introduced into the electroscope and tested as before. It proved to be much more active than the gas from water (three or four times for equal volumes) and as it was very easily obtainable in as large quantities as one wished, it was much more convenient to work with.

In order to compare it with the water-gas the rate of decay of the activity of both gases was observed. For this purpose an electroscope was made as nearly air-tight as possible by the use of solder, sealing-wax and asphaltum varnish, and by regrinding the brass cocks with which it was provided; after some difficulty it was made so tight that, upon being partially exhausted, it would lose less than one-half per cent of its exhaustion in 24 hours. When either gas was introduced into this electroscope, an initial rise of activity occurred lasting for about 0·1 day, followed by a regular decay according to an exponential law in which the activity fell to one-half its value in about four days. The curves for the water-gas and for the earth-gas were indistinguishable when reduced to the same scale; one of them is given in fig. 2. During the initial rise, observations of the leak were made as rapidly as possible, and afterward once or twice a day for about two weeks. As the sensitiveness of the gold leaf varied slightly from day to day,

it was tested after each reading by changing the applied potential by 10, 20, and 30 volts and noting the change in deflection; the readings were then reduced to a standard sensitiveness. We are indebted to Mr. H. M. Dadourian for his assistance in making these numerous and somewhat tedious observations.

The resemblance of this gas to the emanation from radium, in respect to the period of initial rise of activity (which is due to the deposition upon the walls of the electroscope of "induced" or "excited" activity) and also in respect to the

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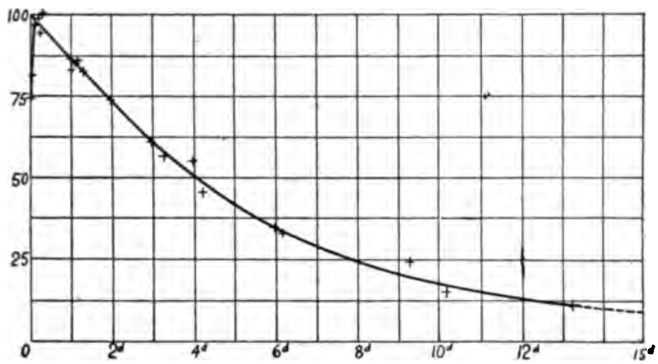

rate at which the activity of the gas itself decays, is so close that we could not hope to detect any differences between the two by means of observations with the electroscope. Accordingly, we had recourse to observations with a quadrant electrometer, and during the autumn, the earth-gas was directly compared by means of the same apparatus with the radium emanation, with regard to the rise of excited activity, the decay of the activity of the gas itself, and the rate of diffusion through a porous plate of unglazed porcelain. The electrometer used was of special construction, made after our design by Mr. L. J. Barrett, mechanician of the Sheffield Scientific School; it proved to be very steady and convenient for the present purpose, and may perhaps be described later, after its behavior under varied conditions has been more fully investigated. When the needle was suspended by a quartz fiber of very moderate thinness, the sensitiveness with 100 volts on the needle was about 250^{cm} per volt, the scale being one meter distant from the mirror. As this was sufficient for our present needs, no attempt to increase it by using a finer suspension was made, particularly as we wished to make observations, in some cases, in as rapid succession as possible and a very large period of the needle was, therefore, undesirable.

A cylindrical condenser (fig. 3), 37^{cm} high and 12·5^{cn} diameter, was made of heavy galvanized sheet-iron with ri of planished brass, A, and A′, soldered to flanges at top bottom; at the top, the guard plate, B, rested upon a rub gasket and was bolted to A by eight small bolts provided v ebonite bushings so that the cylinder was insulated from which was kept earthed. The central rod, C, passed through ebonite collar, D, and the joints about the collar were carefi made tight by sealing-wax. At the bottom, the brass plate was similarly bolted to A′ with a gasket between, but no bu ings were needed in this case, and the heads of the bolts w

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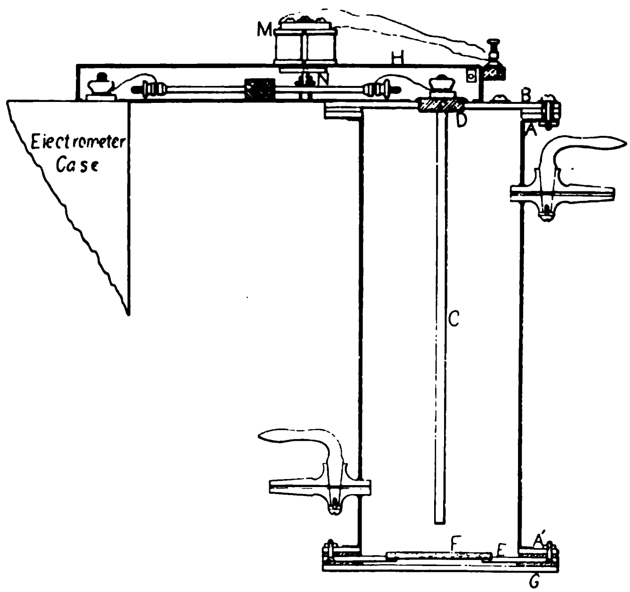

counter-sunk in the bottom surface of E; this plate had a h in the middle, and above it the porous plate, F, was faste with sealing-wax. Another plate, G, also provided with a g ket, was clamped below this by eight small iron screw clan so that it could be easily removed at any time and the por plate exposed. The connection to the electrometer was a br rod supported by ebonite in a rectangular brass box, H, wit hinged lid; this box rested on the guard plate, B, and on case of the electrometer, and two holes in its bottom adı ted the binding screws of rod in the cylinder and of the elec meter. Ordinarily the rod and pair of quadrants connectec it were earthed by N, which was hinged to the box and res

on the connecting rod; by means of the little electromagnet, M, fastened to the lid of the box, N could be lifted off the rod and the quadrants could thus be insulated without the slightest jar. The short-circuiting contact was made of the same piece of brass on both sides, was small in area, and the distance moved was short; there was thus no trouble from contact potential differences. A small hole through the brass box, opposite the binding screw of the electrometer, enabled one to test the sensitiveness of the electrometer from time to time. When the gaskets were well greased with stiff mutton-tallow, the cylinder retained a pressure in excess of that of the atmosphere without perceptible diminution in twenty-four hours.

The gas to be tested was put into the cylinder and readings were made as rapidly as possible during the rise of the induced activity. After the ionization had reached a steady value, the gas was allowed to stand in the cylinder for several days, and readings were taken from time to time to determine the rate of decay of the activity of the gas; as this change was slow, the average of four readings was taken at each observation. Finally the lower plate was removed and the gas allowed to diffuse through the porous plate, readings being taken as rapidly as possible in the meanwhile. From all these readings the leak due to the so-called spontaneous ionization of the air in the cylinder was always subtracted. The potential applied to the cylinder (90 volts) was more than enough to give the saturation current in all cases. The radium emanation used was obtained by bubbling air through a solution containing 0·1 gram of the very impure radium bromide prepared a year or two ago by De Haen; its activity is about 1000 times that of uranium, so that the solution contained probably less than 0·1 milligram of radium. Three small bubbles drawn through this into the cylinder (perhaps a fifth of a cubic centimeter) caused an ionization about six times as great as $1\frac{1}{2}$ liters of the earth-gas; the chief difficulty with the emanation was to get a small enough quantity into the cylinder.

Comparison of the Rates of Decay.

If we assume the exponential law of decay of the radio-activity $I=I_0e^{-\kappa t}$, the constant κ may be determined from any two observations (or two sets of four observations) taken at different times after the excited activity has ceased to rise. Several such determinations were made for the earth-gas and for the radium emanation and are given in the following tables; t in the formula is measured in hours.

It will be seen that the agreement is well within the limits of accuracy of the experiments. This constant for the radium

Earth-Gas.		Radium Emanation.	
Interval in hours.	κ.	Interval in hours.	κ.
19·31	0·00784	20·00	0·00703
24·32	0·00702	23·31	0·00739
43·63	0·00738	22·61	0·00787
		65·93	0·00745
Av. 0·00741 ± ·00016		Av. 0·00744 ± ·00012	

emanation has been determined by P. Curie* and by Rutherford and Soddy† and, when reduced to the hour as the unit of time, the value obtained by Curie is 0·00724, while Rutherford and Soddy obtained 0·00778. Curie's measurements were made with the emanation in a sealed glass tube, and there could thus have been no acceleration of the apparent rate of decay by escape of the gas. The lower value obtained by us would be accounted for if one-half per cent of the emanation leaked from the cylinder in twenty-four hours. Such a lack of tightness is by no means impossible. Rutherford and Soddy's experiments were made with emanation stored in a gas-holder and drawn off from time to time for testing; a slightly greater rate of leak from their gas-holder might account for the higher value of κ obtained by them.

The Rise of the Excited Activity.

It has been observed by Rutherford that the excited activity due to the radium emanation does not decay according to a simple exponential law, and this we find to be the case also with the excited activity due to the earth-gas. The most practicable method of comparing the two seems therefore to be to reduce the measurements on the two gases to the same scale and to plot a curve for each. Two such curves are found in figs. 4 and 5.

In the reduction to the same scale, the mean of the last four observations has been taken as 100. The following tables give the actual measurements and the plotting scale:

Earth-Gas.

Time in minutes.	Observed ionization.	Plotting Scale.	Time in minutes.	Observed ionization.	Plotting Scale.
3·5	1·98	59·3	92·0	3·21	96·1
12·0	2·28	68·3	102·0	3·08	92·2
20·0	2·49	74·6	121·5	3·42	102·4
26·4	2·62	78·4	139·5	3·35	100·3
33·0	2·60	77·9	223·5	3·36	100·6
42·0	2·75	82·3	240·5	3·36	100·6
62·0	2·86	85·6	273·5	3·21	96·1
76·0	3·05	91·3	284·5	3·43	102·7

* P. Curie, C. R. cxxxv, p. 857, 1902.

† Rutherford and Soddy, Phil. Mag. (6), v, p. 445, 1903.

RADIUM EMANATION.

Time in minutes.	Observed ionization.	Plotting Scale.	Time in minutes.	Observed ionization.	Plotting Scale.
3·0	11·23	52·9	90·75	20·28	95·5
8·1	11·66	54·9	100·75	20·17	95·0
12·75	14·98	70·5	105·75	21·18	99·7
16·75	14·88	70·1	110·75	21·68	102·1
20·75	15·82	74·5	115·75	21·12	99·5
25·75	16·16	76·1	120·75	21·12	99·4
30·75	17·20	81·0	125·75	20·92	98·5
37·75	16·87	79·4	135·75	21·52	101·3
42·75	17·68	83·3	145·75	21·45	101·0
47·75	17·70	83·4	205·75	20·52	96·6
52·75	18·05	85·0	220·75	22·18	104·5
57·75	18·58	87·5	268·75	18·78	88·4
62·75	18·88	88·9	278·75	21·44	101·0
69·75	19·32	91·0	282·75	21·25	100·0
76·75	20·10	94·7	287·75	21·35	100·5
82·75	20·18	95·0	292·75	20·92	98·5

The following values taken from the plotted curve will give an idea of the agreement between the behavior of the two gases:

RISE OF EXCITED ACTIVITY.

Time in minutes.	Earth-Gas.	Radium Emanation.
20	74·6	74·4
40	81·0	81·9
60	86·6	87·9
80	91·6	93·4
100	96·0	97·5

The earlier part of the curves in figs. 4 and 5 ($t < 20$ min.) can not be very accurate. It took about two minutes to introduce the earth-gas, and to make the two experiments as nearly alike as possible the same time was consumed in admitting the radium emanation; the zero of the time scale in the curve is the middle of this interval. Few observations could be taken and the curve is so steep that small errors have a great effect upon the point where the curve cuts the axis. Moreover, the results of the diffusion experiment cannot be reconciled with so small a value of the initial activity of the gas, as will be seen; and a special experiment in which radium emanation was introduced rapidly indicated that the initial activity was between 50 and 60 per cent of the final activity. But the question could not be decided very positively with our apparatus, since the slowness of the return of the needle to its zero did not permit readings to be taken in very rapid succession.

Diffusion through a Porous Plate.

Figures 6 and 7 exhibit the results obtained when the bottom plate was removed and the gas allowed to diffuse through the

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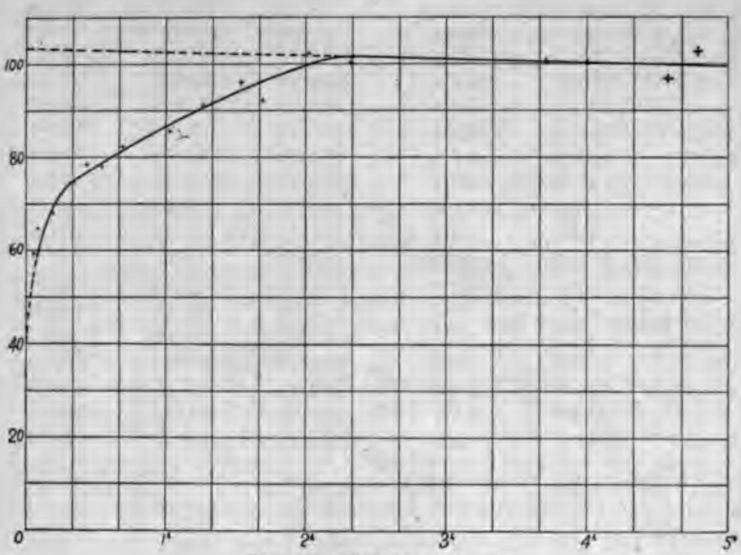
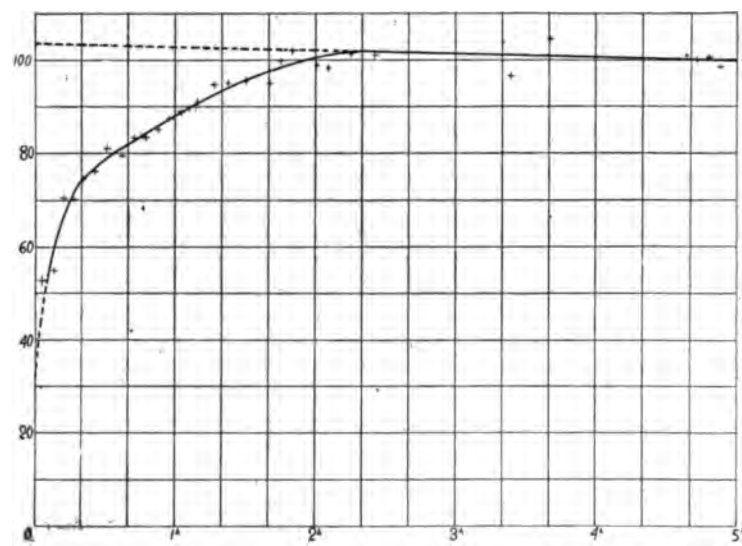


Excited activity; earth-gas.

5



Excited activity ; radium emanation.

porous plate; the time is counted from the removal of the plate. As before, the readings are reduced to the same scale, the mean of four readings just before the plate was removed being taken as 100.

EARTH-GAS.

Time in minutes.	Observed ionization.	Plotting Scale.	Time in minutes.	Observed ionization.	Plotting Scale.
0·0	2·81	100·	79·5	1·62	57·7
2·5	2·81	100·	100·5	1·52	54·1
8·0	2·68	95·4	115·5	1·26	44·9
13·0	2·70	96·1	130·5	1·12	39·9
18·0	2·60	92·5	145·5	0·93	33·1
24·0	2·42	86·1	160·5	0·82	29·2
30·5	2·39	85·1	175·5	0·67	23·8
40·5	2·28	81·1	190·5	0·59	21·0
50·5	2·06	73·3	205·5	0·49	17·4
60·5	2·00	71·2			

RADIUM EMANATION.

Time in minutes.	Observed ionization.	Plotting Scale.	Time in minutes.	Observed ionization.	Plotting Scale.
0·0	12·98	100·	59·0	8·92	68·7
4·0	12·43	95 8	64·0	8·32	64·1
8·0	12·08	93·1	69·0	7·26	55·9
11·0	12·20	94·0	74·0	8·04	61·9
17·0	11·47	88·4	102·0	6·38	49·1
21·0	11·26	86·7	110·0	5·52	42·5
26·0	10·99	84·7	115·0	5·72	44·1
31·0	10·61	81·7	119·0	5·28	40·7
37·0	10·44	80·4	226·0	1·84	14·2
50·0	9·34	71·9	230·0	1·72	13·3
54·0	9·14	70·4	235·0	1·64	12·6

The following table taken from the curves gives a comparison of the two gases:

DIFFUSION.

Time in minutes.	Earth-Gas.	Radium Emanation.
20	90·	87·6
40	80·2	76·6
60	70·6	66·0
80	60·5	56·9
100	51·8	48·5
120	43·6	41·2
140	36·0	34·6
160	29·4	28·8
180	23.8	23·7
200	18·9	19·3
220	[14·5]*	15·8
240	[11·0]*	12·0

* Extrapolated.

The agreement is not altogether satisfactory, but the character of the differences would seem to show that they are due to

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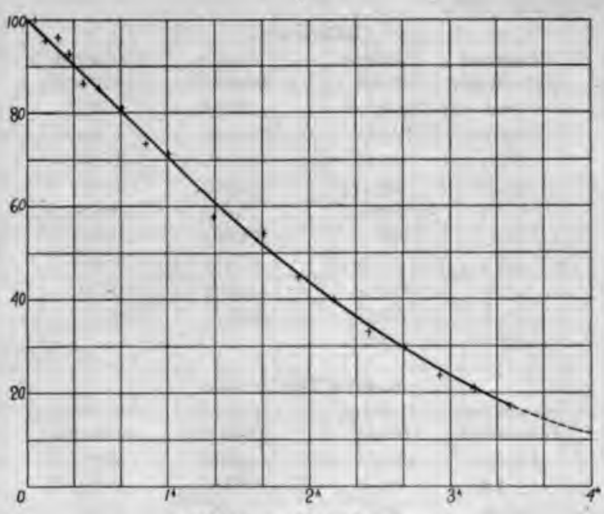
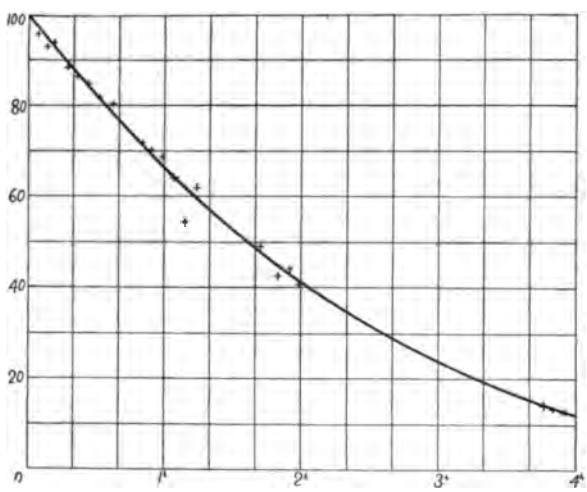


Diffusion of earth-gas.

7



Diffusion of radium emanation.

experimental errors and not to differences in the gases. In the earlier portion of the experiments the earth-gas appears to

diffuse more slowly than the radium emanation and later it diffuses more rapidly. It is difficult to see how this could be the effect of an admixture of either a heavier or a lighter radio-active gas; and the close agreement between the total amounts, diffusing out in four hours (89 per cent and 88 per cent, respectively), together with the close similarity in the rates of decay and of the production of induced activity, show that if any other radio-active constituent is present in the ground air it must be in very small proportion.

Density of the Radium Emanation.

The observations already recorded afford a value of the density of the gas (assuming that Graham's law may be applied) provided the rate of diffusion of a gas of known density through the porous plate is determined. For this purpose carbon dioxide was introduced into the cylinder, allowed to stand until thoroughly mixed with what air remained, and the amount determined by drawing a certain fraction into a burette and absorbing with caustic soda. The porous plate was then exposed for 10 or 15 minutes and the bottom plate again clamped on; after allowing time for thorough mixture, the amount of CO_2 was again determined. Three such observations, with different times of diffusion, gave the following values for μ_1, in the formula $\rho=\rho_0 e^{-\mu_1 t}$ (t measured in hours):

$$\begin{array}{c} 1{\cdot}18 \\ 1{\cdot}15 \\ 1{\cdot}15 \\ \hline 1{\cdot}16 \end{array}$$

In the diffusion experiments with the radio-active gas, if it were not for the presence of the induced activity, the curves, figs. 6 and 7, might be expected to be exponential and it would be a simple matter to obtain the corresponding constant, μ, for the radium emanation; but the effect of the induced activity must be taken into account, and this is the more difficult since its rise and decay is not susceptible of a simple mathematical expression. In fact, as Rutherford has pointed out, there are probably two or three different kinds of induced activity, in the case of radium, each being produced and decaying at a different rate. In order to make the calculation somewhat more manageable, it is assumed in what follows that the rise and decay of the induced activity does follow the exponential law; it will be seen in the outcome that this assumption cannot cause a very serious error in the determination of the diffusion constant.

Let

A = ionization produced by the gas at any instant.
E = " " " excited activity.
I = observed ionization.
So that $I = A + E$.

As a result of the regular decay of the activity of the gas itself we have

$$A = A_0 e^{-\kappa t}$$

Assuming that we have only one kind of excited activity, its rate of production is proportional to the quantity of gas present, i. e. to A; and its rate of decay is proportional to E, so that

$$\frac{dE}{dt} = aA_0 e^{-\kappa t} - \lambda E \qquad (1)$$

Taking $t = 0$ as the time when the gas is introduced into the cylinder, the solution of this equation is

$$E = \frac{aA_0}{\lambda - \kappa}\left(e^{-\kappa t} - e^{-\lambda t}\right)$$

and the total observed effect is

$$I = A_0\left\{\left(1 + \frac{a}{\lambda - \kappa}\right)e^{-\kappa t} - \frac{a}{\lambda - \kappa}e^{-\lambda t}\right\} \qquad (2)$$

As we have seen, $\kappa = 0{\cdot}0074$ when t is measured in hours, and $\lambda = 1{\cdot}36$ gives an exponential rise of excited activity not greatly different from that observed in figs. 4 and 5; so that during the first two or three hours $e^{-\kappa t}$ is nearly equal to unity, and we have approximately

$$I = A_0\left\{1 + \frac{a}{\lambda - \kappa}\left(1 - e^{-\lambda t}\right)\right\} \qquad (2')$$

The curve expressed by (2) differs from (2′) in that its asymptote is not a horizontal straight line but the curve,

$$A_0\left(1 + \frac{a}{\lambda - \kappa}\right)e^{-\kappa t};$$

and within the time considered this is sensibly an inclined straight line which is shown in figs. 4 and 5; $\frac{a}{\lambda - \kappa}$ is the ratio of the excited activity, after equilibrium has been attained, to the activity of the gas.

After three or four hours $e^{-\lambda t}$ is negligible in comparison with $e^{-\kappa t}$ so that we have sensibly

$$I = A_0\left(1 + \frac{a}{\lambda - \kappa}\right)e^{-\kappa t} \qquad (3)$$

and this justifies the determination of κ by the method pursued above, without regard to the induced activity.

In discussing the diffusion experiment, it is convenient to take the initial instant ($t=0$) as that when the diffusion begins; we have then

$$\frac{dA}{dt} = -\kappa A - \mu A$$

where μ is the diffusion constant for this gas through the porous plate used, and thus,

$$A = A_0 e^{-(\kappa+\mu)t}$$

and

$$I_0 = A_0 + E_0 = A_0\left(1 + \frac{a}{\lambda-\kappa}\right)$$

as before,

$$\frac{dE}{dt} = aA - \lambda E$$

which under the assumed initial conditions gives

$$E = \frac{aA_0}{\lambda-\kappa-\mu}\left\{ e^{-(\kappa+\mu)t} - \frac{\kappa+\mu}{\lambda-\kappa} e^{-\lambda t} \right\}$$

and

$$I = A_0 \left\{ \left(1 + \frac{a}{\lambda-\kappa-\mu}\right) e^{-(\kappa+\mu)t} - \frac{a}{\lambda-\kappa} \cdot \frac{\kappa+\mu}{\lambda-\kappa-\mu} e^{-\lambda t} \right\} \quad (4)$$

and by properly choosing the value of μ this should fit the observations plotted in figs. 6 and 7. In order to get a first approximation to μ we may make use of the initial slope of the curve:

$$\left(\frac{dI}{dt}\right)_{t=0} = -A_0(\kappa+\mu)\left\{ 1 - \frac{a}{\lambda-\kappa-\mu}\left(1 - \frac{\lambda}{\lambda-\kappa}\right)\right\} \quad (5)$$

and since κ is so small in comparison with λ, we have approximately

$$\left(\frac{dI}{dt}\right)_{t=0} = -A_0(\kappa+\mu) \quad (5')$$

As has been pointed out, the value of A_0, that is the activity of the gas itself without the induced activity, is very imperfectly known. If we take the values indicated by the extensions of the curves in figs. 4 and 5 (30 to 40 per cent of the

total), the value of μ obtained from equation (5′) when substituted in (4) will not fit the observations. On the other hand, if it be assumed that between 50 and 60 per cent of the total activity is due to the gas, a reasonably good fit can be secured; and this value of A_0 is also indicated by a special experiment under better conditions in which a larger quantity of radium emanation was admitted rapidly; but even under the best conditions with the electrometer used, readings could not be obtained oftener than every 2½ minutes, and thus the principal weight in the selection of a value for A_0 must be given to the diffusion curve. It is to be noted that the constant, a in (4), as determined from experiment, depends on the value chosen for A_0.

In the following table the second column is calculated from equation (4) with $A_0 = 56$, $\lambda = 1{\cdot}36$, $\mu = 0{\cdot}58$, which value gives a better fit than either 0·57 or 0·59. The third column gives the experimental values for the radium emanation as determined from the curve, fig. 7.

Time in hours.	Calc.	Curve.	Diff.
1	67·5	66·0	+1·5
2	40·2	41·2	−1·0
3	23·0	23·7	−0·7
4	12·9	12·0	−0·9

The differences are considerably less than the differences between the experiments for the earth-gas and the radium emanation; for the former, $\mu = 0{\cdot}56$ appears to give the closest agreement. If we take 0·57 as the value from the two experiments and assume that Graham's law may be applied, we find that the density of the gas is 4·1 times that of carbon dioxide, which would give it a molecular weight of 180.

As our apparatus was conveniently arranged for use with radio-active gases, we attempted to determine the properties of the active gas recently obtained by Strutt* from metallic mercury. We were, however, unable to obtain any evidence of radio-activity from air which had been circulated through hot mercury for fourteen hours; and an increase of ten per cent over the "spontaneous" ionization in the cylinder could certainly have been detected. This would seem to indicate that the gas observed by Strutt was due to some radio-active impurity in the mercury which he used.

In connection with the evidence of the existence of minute quantities of radium in the ground in this vicinity, it is of

* Strutt, Phil. Mag., July, 1903.

interest that small quantities of pitchblende and other uranium minerals are found in Connecticut. The fact, however, that the gas, originally discovered by Professor Thomson in the Cambridge water, has also been found to be mainly, if not wholly, radium emanation,* and that the gas found by Elster and Geitel† in the soil in various places in Germany has the same general characteristics, make it not unlikely that radium may be very widely distributed in the earth, although not always in the surface layers.

Conclusions.

1. The radio-active gas found in the ground and in the surface water near New Haven is apparently identical with the emanation from radium. If any other radio-active constituent is present it can be only in very small proportion.
2. The density of the radium emanation, as determined by its rate of diffusion, is about four times that of carbon dioxide.
3. We were unable to obtain the radio-active gas from mercury, recently described by Strutt, and are therefore inclined to attribute his results to an impurity in the mercury used.

Sheffield Scientific School of Yale University, December, 1903.

* E. P. Adams, Phil. Mag., Nov., 1903.
† Elster and Geitel, Phys. Zeitsch., July 1, 1903.

ART. IX.—*Structure of the Upper Cretaceous Turtles of New Jersey: Adocus, Osteopygis, and Propleura;* by G. R. WIELAND. (With Plates I–IX.)

ONE of the most striking geologic features of New Jersey is the area of Upper Cretaceous Greensand or "Marl" which extends obliquely across the state from the Delaware Bay to Sandy Hook. Few Mesozoic formations yield a richer series of extinct vertebrates; and amongst these, the Testudinates, as here so well represented by marine, littoral, and doubtless land forms, are of great interest and importance from a biologic point of view.

These turtles mainly occur in the "Greensand" with the bones of birds, pterodactyls, dinosaurs, crocodiles, mosasaurs, gigantic fishes, and sharks, not many feet below a prominent and extensive bed of Gryphæas, preceded and followed by marls. There are implied abruptly changing conditions and a near shore; and there is a constant likelihood that there may here be found primitive marine or littoral turtles presenting characters allied to those of the old stocks from which the original marine turtles were derived, a fact which needless to say gives to the investigation of the specimens from the Greensand an exceptional value. For amongst the fundamental skeletal changes exhibited by extinct forms, none are more interesting than those connected with the evolution of flippers. Moreover the manner in which this took place in the turtles is rapidly nearing very complete demonstration. As yet, however, the structure of the Upper Cretaceous turtles of New Jersey has received but brief attention.

The carapace of *Adocus* as figured by Professor Marsh some years since, has made this the best known of these forms. But with this exception the descriptions and figures so far as given have been based on fragmentary material, and there has been little evidence presented as to the character of the limbs. Nevertheless the sand matrix, and the naturally disarticulated and uncrushed condition of the skeletal elements of these fossils (see Plate IX), afford the opportunity for rarely satisfactory study. In the following initial descriptions a more adequate knowledge of three of the genera is for the first time made available.

I. *Adocus punctatus* MARSH.—(With Plates I–IV.)

The genus *Adocus* was first assigned by Cope* to some fragmentary remains from the Upper Cretaceous or Greensand of New Jersey, these having been originally described by Leidy

* Proceedings of the Academy of Natural Sciences, Philadelphia, 1868.

as *Emys beatus.* The name *Adocus* (Gr. Ἀ, privative; and Δωχος, rafter) meaning literally without rafters, happily expresses the fact that the rib heads (with the exception of the first and second and tenth) are diminished to the merest line-like trace on the inner surface of the pleurals. The general characters of the genus, however, remained but vaguely known until the description of the carapace of the new species *Adocus punctatus* by Professor Marsh.* This was accompanied by an excellent woodcut, which is here reproduced. fig. 1.

1

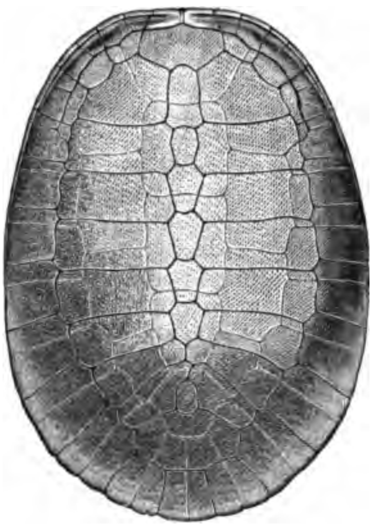


FIGURE 1.—*Adocus punctatus* Marsh (type). Carapace × ⅛.—The original figure by Professor Marsh.

Later the type was placed on exhibition in the Yale University Museum, although no attempt was made to bring the carapace and plastron into their normal position until recently. This having now been done, and this fine type having again been placed on exhibition as finely mounted in erect position by Mr. Hugh Gibb, an opportunity is afforded to supply the much needed figure of the plastron, and present further facts and figures showing the true form of this ornate and interesting Cretaceous turtle.

The remounting of the specimen proves that the outline of the carapace departs from the oval form shown in the original

* Notice of Some Extinct Testudinata. This Journal, vol. xl, 178 and 9, 1890. The type is from the long since abandoned pits of the old Cream Ridge Marl Co. near Hornerstown, Monmouth Co., New Jersey, and was received at the Yale Museum, Oct. 10, 1872.

figure, by a distinct narrowing in the anterior region, so that the greatest breadth is seen two-thirds of the entire length back. A very slight double curvature of the outer border also appears to be present, as shown in Plate 1. It is found, too, that there is less flattening of the carapace than is suggested in figure 1, the curvature rather closely approaching that of *Dermatemys mawii*.* The unusual heavy furrow marking the boundary between the first vertebral and first pleural, also between these two elements and the nuchal and first four marginal horn shields, is shown in the orignal figure, as well as in the additional outline figure (Plate 1) drawn by the writer from the remounted specimen. In the latter figure the sutures are indicated by the serrate lines, and the boundaries of the horn shields by a triple line. With the prominent exception just noted, the other boundaries of the horn shields, though distinct, are indicated by a narrow and shallow groove only. The finely punctate sculpturing of the surface of the carapace is fairly well shown in Plate II, reproduced from a photograph. The punctations are of sub-triangular outline. They appear nearly as if made by the slightly blunted corner of a chisel blade, and approach regularity in their distribution.

The *plastron*, like the carapace, has a punctate surface. The preservation is also exquisite, and the complete trace of all the bony plates and horn shields may be accurately determined, as shown in my outline drawing, Plate III.

Synopsis of the Characters of Adocus.

Carapace.—Of rather elongate sub-elliptical outline, and composed of 48 bony plates with the grooves marking the borders of the 38 horn shields distinct, as follows:—

(*a*) Bony Plates: Marginals 11 pairs, large and heavy, the inner borders uniting solidly with other elements by suture; nuchal large, of sub-pentagonal outline and without nether or costiform processes; pygal as large as nuchal, and of sub-octagonal shape, its boundaries being the 9th neural, 8th pleurals, 11th pair of marginals, and the intervening pygal marginal; pygal marginal large and of sub-quadrilateral form; pleurals 8, the 2d–8th being without rib capitulæ, and the 7th and 8th meeting on the median line; neurals, 7 in all,—there being no true 7th and 8th, *the true 9th* following the interim formed by the median junction of the 7th and 8th pleurals.

(*b*) Horn Shields: A diminutive nuchal and 12 paired marginals, the first four pairs being intermediate in width between the same elements in *Osteopygis* and *Chelydra*, *and the others of large area rising high on the carapace;* 5 vertebralia; 4 pairs

* Table XXI, Gray's Catalogue of Shield Reptiles, Part I. London, 1855.

of costals, the first pair being large and overlapping the inner ends of marginals 1–4; the second and third of nearly the same area, width, and length as the second and third vertebrals. Unlike the 1st, the 2d–4th costals lie entirely on the pleuralia.

Plastron.—Of medium size, the length being two-thirds, and the least width of the bridge one-fourth that of the carapace. Anterior and posterior borders not emarginate, but slightly truncate or "abbreviated." Very heavy, and united to the carapace by sutures (cleidosternal union), with the strong axial and inguinal buttresses meeting respectively the 3d and the 8th marginalia. Composed of 9 heavy bony plates all strongly united by suture, with the narrow line-like furrows marking the borders of the twenty horny shields distinct.

(*a*) The *Bony Plates:* There are the usual eight paired plastrals with a rather large entoplastron of sub-hexagonal outline, and completely enclosed by the epi- and hyoplastra. The heavy axial buttress extends forward to the posterior portion only of the inner edge of the third marginal, and the large inguinal buttress (peduncle) backward to the anterior portion of the inner border of the 8th marginal. The inferior inner borders of these and the intervening 4th, 5th and 6th and 7th marginals pass well in to meet the plastral elements, and the bridge is firmly anchylosed.

(*b*) The *Horn Shields:* Intergular separated by a furrow or semi-divided into paired parts; gulars of sub-isosceles triangular outline; humerals meeting on a straight mesial line; but pectorals, ventrals, femorals and anals on an irregularly sinuous line crossing and recrossing the median sutural junction of the bony elements beneath; three paired inframarginals, axial, mesial and inguinal, with an indistinct small fourth pair well down in the humeral notch. All outlines indicated by fine lines or narrow grooves.

Adocus punctatus a Distinct Species.

In his original description Professor Marsh stated that the present type was most like *A. beatus* of Leidy, and the identity of these species has since been claimed by several. I find however, on comparing the figures of Leidy's type,* that specific differences are to be made out even from the fragmentary materials which constitute it. To make these clear, I show in figure 2 (*a* and *b*) the first left marginals of the forms in question. They are not of the same proportion, nor are the vertebral and marginal horn shields of so nearly the same outline as they would normally be in one and the same species.

* * * * * * *

* Leidy, Cretaceous Reptiles of the United States (Philadelphia, 1865), Plate XVIII, figures 1-3.

As pointed out by Marsh and later by Baur,* the nearest living relative of *Adocus* (the type genus of the Adocidae of

FIGURE 2.—*a*. *Adocus beatus* (type), left 1st marginal. × ½. After Leidy.
b. *Adocus punctatus*, Marsh (type), left 1st marginal. × ½.

Cope†) is *Dermatemys* of Yucatan, which with the genera *Staurotypus* and *Claudius* of Mexico and Central America, constitute the *Dermatemydidæ*.

The arrangement of the neuralia of *Dermatemys* is much the same as in *Adocus*, but there are only 46 plates in the carapace as figured by Boulanger (Brit. Mus. Cat.), the 7th pleural being large and representing the 7th and 8th of *Adocus*. Also, not only the first, but all the succeeding costals overlap the marginals. *Dermatemys* likewise differs markedly in the presence of a costiform process of the nuchal.

Four inframarginals are present, but there are no separate paired gulars as in *Adocus*. Unlike the latter, the plastron is notched posteriorly.

Measurements of Adocus punctatus Marsh (type).
Skeletal parts uncrushed.

(1) *The Carapace.*

Length on straight line	54. cm
Length over curvature	60.
Greatest width (across 5th neural)	37.
Distance over curvature across 5th neural	51.
Projection beyond front end of plastron	6.8
Projection beyond hinder end of plastron	12.2

* Proceedings of the Academy of Natural Sciences, Philadelphia, 1891, vol. xliii, p. 428–430.
† Proc. Amer. Phil. Soc., Philadelphia, 1870, xi, p. 515.

(2) *Bony Plates of the Carapace.*

	Length along outer edge of Carapace.	Middle length from lower edge of Carapace to interior borders.
Nuchal	6·5cm	7·2cm
1st Marginal	6·5	6·5
2d "	5·5	6·5
3d "	5·0	6·2
4th "	4·8	7·0
5th "	5·5	8·5
6th "	6·0	9·3
7th "	6·8	9·5
8th "	7·5	9·8
9th "	6·5	9·6
10th "	6·8	9·4
11th "	6·5	7·0
Median	6·8	6·3

	Length (antero-posterior).	Greatest width (lateral).
Nuchal	6·5	7·2
1st Neural	7·0	4·0
2d "	4·0	2·9
3d "	5·2	3·9
4th "	4·8	3·8
5th "	4·2	3·9
6th "	4·7	3·7
9th "	3·6	2·3
Pygal	7·2	11·2

	Length (laterally).	Width (across middle of plate).
1st Pleural	10·0	8·2
2d "	13·5	5·2
3d "	14·5	5·2
4th "	15·0	5·0
5th "	14·8	4·6
6th "	13·0	4·5
7th "	12·0	3·9
8th "	10·4	4·4

(3) *Carapacial Horn Shields.*

Length of 1st–11th Marginalia respectively, along outer edge of carapace, 6·2, 6·2, 5·1, 5·0, 5·3, 6·0, 6·3, 7·2, 7·5, 7·3, 7·0, 6·8 centimeters.

Length of 1st–4th Costalia respectively, 12·6, 11·8, 10·0, 7·2 centimeters.

Length of the Nuchal scute, 1·6.

Length of the 1st–5th vertebralia respectively, 10·2, 9·1, 10·4, 10·2, 8·3 centimeters.

(4) *Elements of the Plastron.*

	Greatest length on median line.	Greatest lateral width.
Epiplastron	$2·5^{cm}$	$6·5^{cm}$
Entoplastron	5·0	6·8
Hyoplastron	6·0	14·0
Hypoplastron	10·5	14·0
Xiphiplastron	11·	8·

(5) *Plastral Horn Shields.*

	Greatest length on median line.	Greatest lateral width.
Intergular	2·5	3·
Gular	(3·)	(4·)
Humeral	4·	8·5
Pectoral	4·	11·
Ventral	9·0	11·
Femoral	8·5	9·
Anal	7·5	7·

(6) *Thickness of various elements.*

Nuchal (at anterior median border)	$1·1^{cm}$
" (at posterior end)	·3+
1st Neural (at anterior end)	·4
1st " (at posterior end)	1·0
5th " (anterior)	1·0
5th " (posterior)	1·0
7th " (average)	·5
1st Marginal (at the marginal–vertebral–costal horn shield intersection)	2·0
11th Marginal	1·3

II. *Osteopygis Gibbi* sp. nov.—(Plates V–VIII.)

The genus *Osteopygis* was proposed by Cope in 1868* for the reception of certain fossil turtles from the Upper Cretaceous Greensand Bed of New Jersey. In all some seven species have been referred to this genus. But they are quite without exception based on fragmentary material, for the greater part insufficiently illustrated and described. It is hence with the utmost difficulty, if at all, that one may adjudge the value of the several species without having at hand all of the types, which urgently require redescription and adequate illustration. This being the fact, the restoration for the first time of the complete shell of *Osteopygis* must be of immediate service and interest. The possibility of such a restoration is afforded by Yale Specimen No. 783.

* Proceedings of the Academy of Natural Sciences, Philadelphia, 1868, p. 147.

'his finely preserved Carapace and Plastron is accompanied a perfect right Femur and left Humerus, with the proximal l of the left Femur, the distal end of the right Humerus, a fect left Ulna, both ends of the Tibia, the first and second : Metatarsalia, the 7th Cervical centrum, and some fragmeny cervicals.

ll the parts just enumerated are believed to belong to one l the same individual. Lest the question should be raised, ate that the Carapace and Plastron are not composite. It proven that every portion belonged to the same individual. s now mounted and shown in Plates VI and VIII, almost only restoration required was due to the loss of portions of originally complete shell, at the time of collection. Forately, in no case is such restoration hypothetical. Invariy the outlines are delimited by unbroken opposing surfaces rticulations. The most serious loss was in the case of sevl of the neuralia, of which portions of the first and third, l all of the sixth–ninth were lost; but, fortunately, opposed ural unions of these parts with the pleuralia indicate the lines of all these bones. The pleuralia are practically comte, and neatly join. All the marginalia but the left 11th present, complete, uncrushed, and suturally interlocked. will be noted, the 9th neural and the anterior pygal are h distinctly assymmetric.

'hat the accompanying limb bones belonged to this parilar carapace and plastron, is indicated by all the availaevidence. When I began the study of this fossil as eived with its various parts dissociated and some of them ken, I found accompanying it and bearing the same cataue number, 783, a differently weathered left hyoplastral gment, and a perfect left hypoplastron of the same size, and inly of the same species as the plastron belonging to the apace. In addition, there were most of the pleuralia, and eral marginals of a much smaller turtle belonging to the us *Lytoloma*, a much more distinctly marine form. None these turtles can possibly be confused with the individual e described, and they constitute all the parts of the original oment, as received from the West Jersey Marl Company of nsboro, Gloucester Co., New Jersey, May 17, 1870. These tles came from the large marl pits, in the "Upper Greend Beds," one and one-half miles east of the Barnsboro O., at which digging was abandoned about twenty years .

'he present specimen, or 783 proper, clearly belongs to the us *Osteopygis*, as commonly used. Though, of course, as e himself pointed out, this genus may ultimately be referred

to the prior one, *Euclastes*.* For reasons given below, the species is considered a new one, and I take great pleasure in naming it in honor of Mr. Hugh Gibb, Preparateur at this Museum for more than twenty years past, and an excellent naturalist.

3

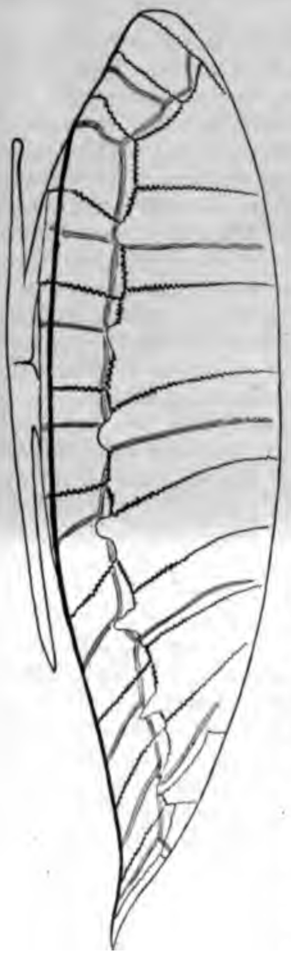


FIGURE 3.—*Osteopygis Gibbi* (type). Sketch of the lateral view of the carapace and plastron as mounted. × 1/6.

Description.—The general outline of the Carapace is broadly subelliptical, the nuchal having only slight recurvature, and the pygal region forming a very obtuse angle.

As may be seen by referring to the side view, figure 3, the body is rather flat. The general outline is not unlike that of *Kachuga lineata*, the plastron being, however, much flatter and quite different. To get any comparison of plastral form, it is necessary to turn to the Dermatemydidæ or to *Chelydra*. The very large posterior marginals rise at a rather low angle. The surface of the bony plates is seldom pitted, except by accident, and is, especially over a large portion of the pleuralia, marked by closely set fine lines.

(A) *Carapace.*—Composed of 51 bony plates, with the boundaries of the 38 horn shields all clearly marked as deep and distinct furrows.

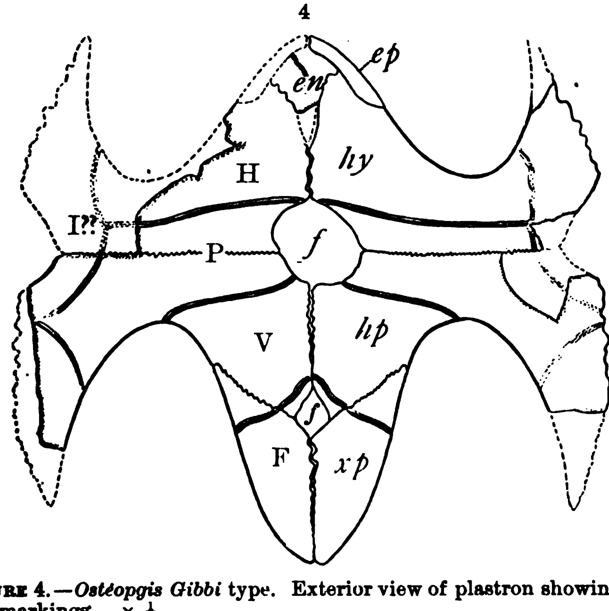
(1) *Bony Plates:* Marginals 11 pairs, all united to pleurals by sutures; the 2d deeply round pitted posteriorly for reception of outer anterior limb of the hyoplastron; the 7th–11th of broadly oblong shape, slightly concave on upper surface, the inferior faces being more strongly convex; external borders forming a continuous outer curvature from the nuchal to the ninth, but borders of 9–11 and the pygal marginal slightly convex; 4th–6th very slightly escalloped on inner upper border and exposing rib tips a little; 7th–10th with deep V-shaped notch in inner upper border distinctly exposing the tips of the ribs; rib pits flattened: mar-

* Extinct Batrachia, Reptilia, and Aves of North America, Trans. Amer. Phil. Soc., vol. xiv, 1869, page 140.

-costal furrow crosses the posterior corner of M1, inner of M2 and 3, nearly or wholly coincides with inner bor- of M4–6 and crosses inner ends of M7–11; nuchal, large, ›entagonal, anterior border nearly without nether or costi- . process, straight as viewed vertically; pygal marginal of :um size, notched anteriorly: pleurals, 8 pairs, all uniting ıtures with the marginals, with the distal ends as broad as, 'oader than, the proximal ends, and the flat ribs projecting ike into pits in the marginals (gomphosis): neurals 9, the 8 about twice as long as broad,—No. 1 with rounded ends, 2–7 notched anteriorly, rounded posteriorly, No. 8, ellipti- No. 9 broader than long. Anterior pygal assymmetrical,— ', uniting with inner border of 10th and 11th marginals; ›rior pygal of sub-trapezoidal outline, broadest in front, with double curve in posterior border for reception of the :iorly notched pygal marginal. (The anterior and posterior l are represented by a single pygal in *Adocus*.)

) *Horn Shields*.—The boundaries of all the horn shields lelimited by uniform deep border grooving on the bony 's: nuchal shield wide; 11 paired marginals, with a

4



ɪURE 4.—*Ostéopgis Gibbi* type. Exterior view of plastron showing horn- l markings. × ⅙.
Bone plates.—*Ep*, epiplastron; *en*, entoplastron; *hy*, hyoplastron; ypoplastron; *xp*, xiphiplastron; *f*, *f*, foramina.
Horn shields.—H, humeral; P, pectoral; V, ventral; F, femoral; 'egion of indistinct inframarginals.

twelfth or supracaudal pair, none of which overlap the ends of the pleuralia; the 4th–10th rising just to, or a little above the bottom of the marginal notch above noted as exposing the rib-tips: costals 4 pairs, large: vertebralia 5, the 1st–3d and 5th of normal pattern, the 4th of ornate outline like the vertical section of a wide-mouthed and small-bottomed jug.

(B) *The Plastron.*—Of much reduced size, the length being about $\frac{3}{5}$, and the least width of the bridge less than $\frac{1}{6}$ that of the carapace. Composed of 9 bony plates, with the furrows marking the horn shields rather indistinct, but evidently as shown in text figure 4.

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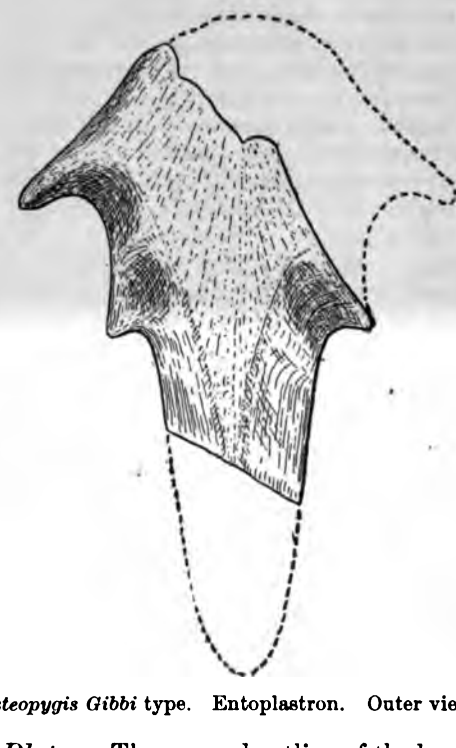

FIGURE 5.—*Osteopygis Gibbi* type. Entoplastron. Outer view, natural size.

(1) *Bony Plates.*—The general outline of the bony plates combines features of *Chelydra* and of the Dermatemydidæ. The narrow epiplastra meet at a rounded obtuse angle as in *Staurotypus.* The entoplastron, as shown in the accompanying text figure 5, exhibits a condition which is intermediate between that seen in a turtle like *Adocus*, and the reduced and rod-like condition in *Chelydra.* Union of the remaining elements on

the median line is by digitation—not by sutnre, with a large assymmetric and sub-oval median foramen at the hyo-hypoplastral, and a much smaller, at the hypo-xiphiplastral junction (*f*, *f*, figure 4). There are also small lateral foramina of crescentic outline between the 5th marginal and the hyo- and hypoplastron, as may be seen in Plate VIII.

The manner of the bridge connection with the carapace is of interest. Although truly dactylosternal, there are distinct suggestions of a former cleidosternal (closely interlocking suture) union as in *Adocus*. The axial and inguinal limbs or buttresses project into sockets in the posterior end of the 2d and the anterior end of the 8th marginals.

6

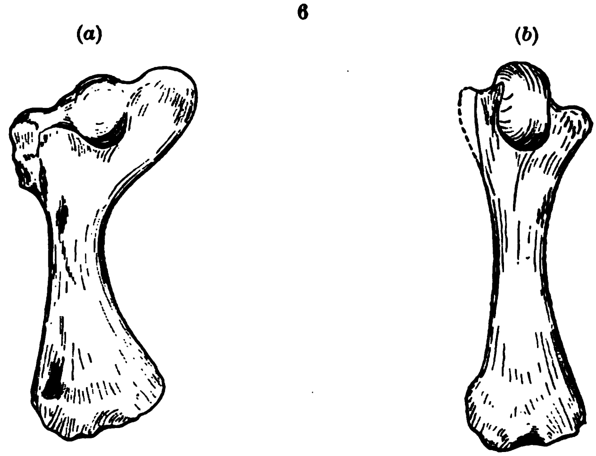

FIGURE 6.—*Osteopygis Gibbi* type. × $\frac{1}{3}$.

(*a*) Left humerus, dorsal view.
(*b*) Right femur, dorsal view, with fibular trochanter shown in dotted outline.

Cope speaks several times of a large rib cavity in the second marginal. But such cannot be present in any species of the genus *Osteopygis*. *The second, or first large rib, projects with strong backward curvature into a long claw-like depression in the third marginal.* The large pit in the second marginal appears to be a remnant of a former hollow beneath the axial buttress, and must serve mainly for muscular attachment, since only the lower edge is occupied by the end of the hyoplastral peduncle. The dactylations between the buttresses are short and robust. Those of the hyoplastron project against the lower inner border of the 3d and 4th marginals, which are pitted for their reception. Those of the hypoplastron project similarly against the 6th and 7th marginals. The hypoplastral

limbs or peduncles however pass gradually beneath the posterior edge of the seventh, and end as mentioned, in the anterior pit of the eighth marginals.

(2) *Horn Shields.*—The boundaries of the plastral horn shields are not all distinct, and these being the only portions whatsoever of either carapace or plastron that are not entirely so, it has been deemed best to indicate them, so far as determined, separately in text figure 4. As there shown, the inframarginal region is not clear. The anterior border of the pectorals, ventrals and femorals is however distinct, anals not being present, or else diminutive as in *Chelydra*. The gular boundaries do not show clearly, but these elements were probably small as in the existing *Staurotypus Salvinii*, with which there is in the general arrangement, number and size of parts a fairly striking comparison.

(C) *Limb and Other Bones.*—The *humerus*, as shown in text figure 6*a*, is in part intermediate between what I have termed the chelic (*Chelydra*) and the *parachelic* (*Testudo*) form.* The proximal end approaches the Chelydran form very distinctly. It is very large and the shaft slender. But the distal end is facetted, and in this respect approaches the grooved character seen in some forms of *Testudo*. The ectepicondylar foramen is a deep perforation. The only well-marked suggestion of departure in the direction of marine forms is afforded by the obtuse angle between the radial and ulnar crest, this being markedly greater than in *Chelydra*.

The *femur*, as might well be surmised in *Osteopygis* from the oval outline of the carapace, is as in *Chelydra* distinctly larger than the humerus (see figure 6 *a* and *b* in text). The

7

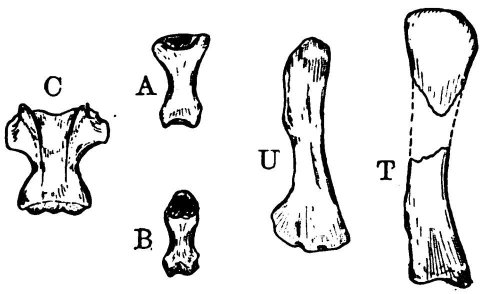

FIGURE 7.—*Osteopygis Gibbi* type. × ⅛.
C, superior view of seventh cervical centrum; A, superior view of first, and B, of the second left Metatarsalia; U, outer view of left Ulna; T, outer view of right Tibia.

* Some Observations on Certain Well Marked Stages in the Evolution of the Testudinate Humerus, this Journal, vol. ix, 1900, 413–424. See also, L'Evolution des Chéloniens Marin par L. Dollo, Bull. Acad. Roy. Belgique Cl. Sc. (Aug. 9, 1903).

most distinctive feature is the continuation of the articular surface well out on to the fibular crest. The distal end, as in the humerus, is facetted, not smooth. The characters of the ulna and of the tibia, and the several phalanges present, are in the main quite comparable feature by feature with these several elements in *Chelydra* (see text figure 7).

Of great interest is the form of the limbs. It is not to be said off hand that *Osteopygis* had flippers, as is implied by placing the genus in the Chelonidæ, as has been done in the American edition of Zittel's Handbuch. The limb bones above made known are not entirely conclusive on this point. The best study of the evidence at hand may be made from the following tabular statement:—

	Chelydra.	Osteopygis.	Eretmochelys.
Length of shell	(26·)	74·	(37·)
" humerus	6·	14·5	8·
" femur	6·4	15·	6·
" ulna	3·5	8·	4·
" 1st metatarsal	1·1	3·4	1·4
Ratio to length of shell.			
humerus	4·3	5·1	4·6
femur	4·0	4·9	6·1
ulna	7·4	9·2	9·2
1st metatarsal	23·6	21·8	26·4

The larger the ratio the smaller the part, whence *Osteopygis Gibbi* has a relatively shorter femur, humerus and ulna, with a longer metatarsal than *Chelydra*. But the humerus is relatively shorter than that of *Eretmochelys*, the femur relatively much longer. Comparison of the metatarsal in *Eretmochelys* cannot however be readily made since the hind flipper of the latter is so very greatly reduced. The conclusion I am led to is that the present species had by no means so well developed flippers as I have shown the primitive sea turtle *Toxochelys** to have had. But as the phalanges had undergone some elongation the toes must at least have been strongly webbed though doubtless they yet retained their claws. The smooth distal end of the humerus of the closely related *Propleura* is considerably more like that of the marine or natatorial types, and may indicate that these forms were undergoing some adaptation of the limbs for a pelagic or a littoral habitat. It would however seem that the marine Chelonians destined to survive were those which early acquired relatively powerful humeri, and it is probable that a form with a long femur like *Osteopygis*, even if the feet were fairly developed as flippers, was

* Notes on the Cretaceous Turtles *Toxochelys* and *Archelon* with a classification of the Marine Testudinata. This Journal, vol. xiv, 1902, p. 95.

not so good a swimmer as any of the existing marine turtles. In any case it is very evident that *Osteopygis* and the following closely related *Propleura* are among the most interesting of all known forms on the border line between littoral and marine Chelonians.

The 7th cervical is coelo-bicyrtean, the double convexity of the posterior end not being very marked. It is very broad in front, mainly because of heavy somewhat downwardly directed transverse processes, and had a heavy median keel running along its full length. The base of the neural arch is rather slender. Regarding the skull of *Osteopygis* we are as yet uncertain. It may prove to be like that of the prior genus *Euclastes*, as was thought possible by Cope or has since been assumed on ground not known to me. This remains to be carefully proven or disproven.

Systematic Position.—The type of the genus *Osteopygis* is the species *O. emarginatus*, and the present species appears to be more nearly related to it than to any of the several subsequently described forms. The type specimen of *Osteopygis Gibbi* differs from *O. emarginatus* in having a convex (not slightly concave*) outer surface of the 1st marginal, and in the conformation of the horn shields of the posterior marginals, several being distinctly smaller. Also the marginals are not notched. The lack of figures, and the fragmentary condition of the type, prevent further comparison.

In the case of *Osteopygis platylomus*, which has well marked pleuro-marginal fontanelles, the differences are clear, and it is not entirely certain that this species falls within the genus *Osteopygis*, which as hitherto constituted is quite certainly too far extended.

There is no living form to which *Osteopygis* can be at all so nearly compared as can be *Adocus* to *Dermatemys*. But if the carapace only be considered, there is a certain resemblance to such forms as *Kachuga* and *Hardella* (Burma and Pegu). On the other hand, there is marked similarity between the plastron of *Osteopygis* and that of *Staurotypus* of Central America. Moreover the carapace of this latter genus presents certain features that seemingly could have been derived from some ancestral *Osteopygid* form by fusion of parts, especially in the pygal region. It is therefore with the existing Central American genus *Staurotypus* that we may best compare *Osteopygis*, the differences however being of full family value. It is also very interesting how the dorsal characters of such a pleurodiran as *Plesiochelys solodurensis* (Upper Jura, Kimmeridgian) are strikingly like those of *Osteopygis*, while the plastron is almost identically like that of *Adocus*.

* Proc. of the Phil. Acad., May 12, 1868, p. 147.

—As to the exact systematic position of the family to which *Osteopygis* (and *Propleura*) belong I feel abundantly justified in for the present withholding final judgment, but think it would seem best for the time being to retain these genera in Cope's Propleuridæ, and separate *Lytoloma* in another family, the Lytolomidæ.

Measurements of Osteopygis Gibbi.
(Skeletal parts uncrushed.)

(A) *The Carapace.*

Length on straight line	$74{\cdot}3^{cm}$
" over curvature (greatest)	69·0
Greatest width	58· ±
Projection beyond front end of plastron	9·4
" " hinder " "	22·4

(1) *Bony Plates of the Carapace.*

	Exact length on outer edge of Carapace.	Length from lower edge of Carapace to union with pleurals.
Nuchal	$12{\cdot}7^{cm}$	----
1st Marginal	7·9	$6{\cdot}\ ^{cm}$
2d "	8·2	6·
3d "	7·5	6·1
4th "	7·6	6·
5th "	8·0	6·4
6th "	8·5	6·2
7th "	9·2	8·1
8th "	9·5	10·5
9th "	9·3	10·5
10th "	9·0	11·1
11th "	8·3	11·0
Median or Pygal Marginal	8·3	(7·1)

	Length.	Greatest width.
Nuchal	·7·5	14·5
1st Neural	9·5	4·1
2d "	6·5	4·7
3d "	6·5	4·7
4th "	6·5	4·3
5th "	(5·)	3·7
6th "	(4·5)	3·3
7th "	(4·5)	3·0
8th "	(6.5)	(3·8)
9th "	(2.0)	(4·3)
Pygal (anterior)	6·	16·2
" (posterior)	6·	9·7
" marginal	7·1	8·3

	Length (laterally) over curvature along posterior sutural border.	Width across middle.
1st Pleural	21·0cm	10· cm
2d "	25·0	7·5
3d "	28·0	7·0
4th "	27·0	6·8
5th "	22·0	6·5
6th "	19·0	5·0
7th "	16·0	5·4
8th "	9·0	5·5

(2) *Carapacial Horn Shields.*

Extreme width of Nuchal .... 9·0cm

Length of 1st–11th Marginalia, respectively, along outer edge of carapace:—
5·4, 8·0, 8·1, 8·5, 7·3, 8·5, 9·5, 9·7, 9·7, 9·5, 8·0, 8·4cm

Greatest lateral length of 1st–4th Costalia, respectively,
21·0, 25·0, 22·0, 16·0cm

Greatest antero posterior length 1st–5th Vertebralia, respectively, 11·0, 14·0, 13·5, 14·0, 14·5cm

(B) *The Plastron.*
(Shields, Bony Plates.)

Length	43·0cm
Width, greatest	48·
Distance between axial and inguinal buttresses	38·5
Length of Epiplastron	9· ±
Width of Entoplastron	5·9
Least width across the hyo- and hypoplastral bridge	11·4
Greatest length of Xiphiplaston	18·5
" width of "	5·5

(C) *Other Skeletal Parts.*
(1) The *Humerus.*

Extreme length	15·1 cm
Distance from outer border of radial to end of ulnar crest	7·5
Diameter of head (dorso-ventral)	3·0
Dorso-ventral thickness of middle of shaft	1·8
Greatest distal width	5·2
Distance of ectepicondylar foramen from anterior border	·8

(2) *Femur.*

Extreme length	15·1
Antero-posterior diameter of head	2·3
" " " of middle of shaft	1·85
Greatest or antero-posterior distal width	4·5
(3) Greatest length of ulna	8·3
(4) " " of 1st metatarsal	3·4
(5) " " of 2d "	3·1
(6) " " of 7th cervical centrum	3·8

(D) *Thickness of Certain Bones of Carapace.*

Nuchal on median line	1·6cm
" at ends	1·7
2d Marginal at anterior end	2·1
8th " " border	2·6
8th " posterior "	1·4
9th " " "	1·4
Thickness 3d Marginal near inner border	0·6
7th Pleural at distal end	0·6

III. *Propleura Borealis* sp. nov.—(Plate IX.)

A new species belonging to a different genus from *Osteopygis*, but to the same family, the Propleuridae of Cope, is indicated by Yale Specimen No. 778, from the old Cream Ridge Marl Company's Pits, near Hornerstown, Monmouth Co., New Jersey. This fine Upper Cretaceous turtle was received at the Yale Museum in May, 1870. It consists in the nuchal; 1st and 2d neuralia; the 2d, 3rd, 5th, 6th and 7th right, and the 1st, 2d, 3rd, 5th and 6th left marginalia; the 1st and 2d, the 4th and 5th right pleuralia, with the 1st and 2d left pleuralia; the hyoplastron and hypoplastron of the right side, with both xiphiplastra; the left humerus, the pubis and ilium of the left side, and both ischia. None of these bones are crushed, and they are mostly little or not at all broken, and in a fine state of preservation, as may be seen by reference to Plate IX, where a photograph of all is given, the elements of the Carapace being placed in their approximately natural position, with the grooves marking the boundaries of the horn shields marked in ivory black water color. The portions of the plastron present are but very little broken, the view given being ventral, just as if the parts were brought out from their natural position beneath the carapace and to one side. Note that the antero-exterior limb of the plastron so often broken away in dactylosternal fossil plastra is entire. It projected into a pit at the posterior end of the second marginal, in the manner also seen in *Osteopygis*, and the interesting form of dactylate plastral union described above for that genus is also repeated in the present turtle. The humerus was broken in two, but the edges of the fracture unite solidly.

The pelvic elements unfortunately have their median symphysial borders broken away, but so much is present as to abundantly warrant their restoration, as shown laid flat and seen from the ventral side on Plate IX.

Description and Comparison with Osteopygis.

The form before us I shall, reviving Cope's genus, call *Propleura borealis*.* The specific name may serve to lay

* Extinct Batrachia, Reptilia, and Aves of North America. Trans. Amer. Phil. Soc., vol. xiv, 1869, pages 188 et seq.

stress upon the fact that the nearest relatives of this turtle and its congeners are, so far as yet present in existing faunas, now mainly to be found in far southern lands. The species is next related to *Propleura* (Osteopygis) *erosa* of Cope, and to the type of the genus *Propleura* (Osteopygis) *sopita* as further noted below.

The arrangement of the plates and horn shields approaches that of *Osteopygis*, but there are many differences, the citation of which following the notes already made on this genus will answer quite fully the purposes of description. The differences follow:—

(*a*) The surface of the bones of the Carapace is not smooth to fine lined, as in *Osteopygis*, but coarsely round pitted to uneven depths, as if by numerous rain drop impressions of different sizes. Comparison of the surface of the various parts of the skeleton shows that while there are pittings present that may be ascribed to accidents of preservation, the characteristic pitting of the Carapace as shown in the plate is a true surface sculpturing. The pits are from 1 to 6^{mm} across, and from 1 to 3 or 4^{mm} deep, the average size being about 3^{mm} in diameter by 2^{mm} in depth.

(*b*) The proportion of the carapacial parts is quite different from that seen in *Osteopygis*. The nuchal has much more anterior concave curvature than in *O. Gibbi*, and though scarcely broader or longer, is nearly twice as thick. Contrariwise, the relatively much heavier second marginals are longer.

(*c*) The external border of the 6th and 7th marginals is notched at the boundary line of the horn shields, not unbroken as in *O. Gibbi*.

(*d*) The interior borders of the marginals present, following the anterior two-thirds of the second, which like all that of the first unites with the 1st pleural by suture, are smooth. Also the outer corners of the rib plates following the first end in oblique smooth edges, thus forming a series of well marked lateral or pleuro-marginal fontanelles, which lie opposite the marginal junctions beginning with the 2d and 3d, and likely extending to the 9th and 10th. These are of broad crescentic outline, and the one bounded by the 6th and 7th marginals and the 4th and 5th pleurals is 7^{cm} long and about half as wide. See Plate IX. There are no pleuro-marginal fontanelles in the distinctly smaller turtle *Osteopygis Gibbi*, and probably none in any specimen justly referable to the genus. Such fontanelles formed at the outer edges of the pleuralia constitute an anatomical feature that is quite different from the marginal notch over the 3d–9th rib tips as in *Osteopygis*.

(*e*) The rib pits are of rounded conical shape, and not flattened.

(*f*) The humerus of specimen 778 has much more rugose radial and ulnar crests than that of *Osteopygis*. Also corresponding well with the presence of pleuro-marginal fontanelles, the distal end is well rounded like that of *Chelydra*. The general form is chelic to chelicoid. The angle between the proximal crests is much more obtuse than in any of the Chelydridæ, and the ectepicondylar foramen is well enclosed. This latter is a retained primitive position.

The Pelvis.—The pelvis of the type just described is fortunately present as mentioned above, and can only be given separate description, since this portion of the skeleton of *Osteopygis* and allied forms has not hitherto been known. Although the median symphysial borders of both the pubes and ischia are broken away, the remainder of the pelvic outline is quite entire, and has warranted the restoration shown in Plate IX. There the parts are shown laid out flatwise and as seen from their lower, that is, from the acetabular side. The general structure and outline of parts is much like that seen in *Chelydra*, except that the distal articular surface of the pubis is much longer as in the marine turtle *Toxochelys*, which also has a somewhat Chelydra-like pelvis.

It is to be noted that the preceding facts and comparisons indicate a turtle close to *Propleura* (Osteopygis) *erosa* Cope, the type of which has not been figured. Cope says the species *O. erosus* has vertebral bones more than twice as long as wide, which *is not the case* in the 1st and 2d vertebrals, the only ones preserved, in the turtle before us. Completer knowledge of the two species may, however, show their identity. From *Propleura* (Osteopygis) *sopita* separation is based on the different proportions of the marginals, though in most other respects there is close agreement so far as may be adjudged from the fragmentary type material described and figured.* But generic separation of these specimens from *Osteopygis* must hold as based on the presence of well-marked lateral pleuro-marginal fontanelles, conical rib pits of the marginals, and humeri with smooth not sculptured distal ends.

Measurements of Propleura borealis.

Greatest width of Carapace		65·6^{cm}
Length of Marginals measured along the outer edge:		
1st Marginal		10·0
2d	"	9·5
3d	"	7·5
4th	"	
5th	"	9·0
6th	"	10·4
7th	"	11·0

* Extinct Batrachia, Reptilia and Aves, Plate VII.

Length over curvature measured along posterior sutural borders.	
1st Pleural	21·0 cm
(2d ")	23·0
3d "	25·0
4th "	24·0
5th "	21·0
Width of Nuchal measured along anterior border	14·0
Greatest width of Nuchal	18·5
Anterior posterior length of Nuchal	9·0
Anterior-posterior length of first Neural	10·2
Greatest width 1st Neural	5·5
Greatest width 2d Neural	5·7

The Plastron.

Greatest lateral width of the hyoplastron	25·0
" " " hypoplastron	17·0
Length along median line of interdigition of Xiphiplastra	11·0

The Pelvis.

Distance from lower outer border of acetabular surface to base of the ento-ectopubic notch (or curve)	6·2
Distance from acetabulum to base of inner post ischial curve	5·5
Least distance from center of acetabulum to extremity of ilium (or surface of iliac support on carapace)	8·0

The Humerus.

(Normal in every respect.)

Extreme length	17·0
Distance from outer border of radial to end of ulnar crest	7·8
Diameter of head (dorso-ventral)	3·25
Dorso-ventral thickness of shaft	1·7
Greatest distal width	5·4
Distance of entepicondylar foramen from anterior border	1·1

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ART. X.—*Studies of Eocene Mammalia in the Marsh Collection, Peabody Museum;* by J. L. WORTMAN.

[Continued from vol. xvii, p. 33.]

Omomys pucillus Marsh.

Hemiacodon pucillus Marsh, this Journal, 1872, p. 22, Separata.

The type of this species, figure 124, consists of a fragment of a right mandibular ramus bearing the second molar, the structure of which agrees very closely with that of the corresponding tooth of *O. Carteri*, but the former is distinctly smaller. A second jaw fragment in which the second and third molars are preserved undoubtedly belongs to the same species. In my own collection, there are two jaw fragments in association with two superior molars, and in the Marsh collection there is one entire series of superior molars. These additional specimens, figures 125 and 126, furnish as complete a knowledge of the dentition as that described in the foregoing species. The dental formula of the lower jaw is the same as in *O. Carteri*, and with some few exceptions, which are of no more than specific importance, the details of structure are very similar. The chief distinctions separating *O.*

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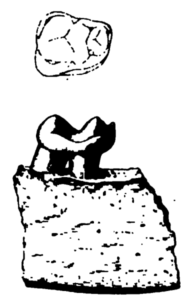

FIGURE 124.—Jaw fragment containing the lower molar of the right side of *Omomys pucillus* Marsh (type of *Hemiacodon pucillus* Marsh); side and crown views; a little more than four times natural size.

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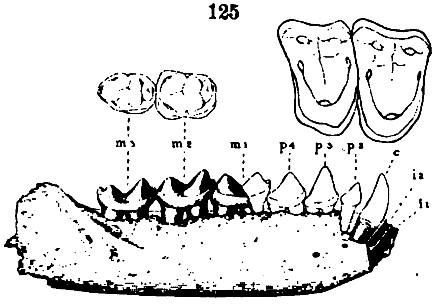

FIGURE 125.—Lower jaw and two superior molars of *Omomys pucillus* Marsh; side view of lower jaw, with side and crown views of teeth, and crown view of superior molars; the last are represented in outline five times natural size, while the lower jaw is a little less than three times natural size, and is drawn from three specimens.

pucillus from *O. Carteri* are the following: The species is considerably smaller; the last lower molar is slightly more reduced,

and there is a distinct ridge descending from the external cusp of the heel into the valley—a structure which is wanting in *O. Carteri;* the crown of the last upper molar is not so pointed internally; the postero-internal cusp is better developed upon the second than on the first molar; the intermediates are a little less distinct than in *O. Carteri.*

The species is thus far known from the lower and middle horizons of the Bridger.

Omomys Ameghini sp. nov.

A third still smaller species, which I refer provisionally to this genus, is represented by a fragment of a lower jaw of the left side, containing the second and third molars, figure 127. Besides being smaller in size than that of *O. pucillus*, the trigon is elevated above the heel to a much greater extent. This gives a somewhat insectivorous appearance to the teeth, but they are otherwise as in the species of *Omomys.*

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Figure 126.—Crown view of three superior molars of the right side of *Omomys pucillus* Marsh; two and one-half times natural size.

Figure 127.—Jaw fragment of the left side of *Omomys Ameghini* Wortman; side and crown views; two and one-half times natural size. (Type.)

The last molar is little reduced, and the anterior cusp of the trigon is distinct in both the second and third.

The locality from which the specimen was obtained is not mentioned on the label, unfortunately, so that its exact horizon is unknown. The specimen was found by Mr. J. W. Chew.

Omomys uintensis Osborn.

Microsyops uintensis Osborn, Bull. Amer. Mus. Nat. Hist., 1895, p. 77; ibid., June 28, 1902, p. 202.

This species of *Omomys* was founded upon a fragment of jaw from the Uinta, containing the third and fourth premolars and the first and second molars. The specimen is preserved in the American Museum collection, and has recently been figured by Osborn in his paper on the American Eocene Primates. At the time of its description, Osborn referred the specimen to the genus *Microsyops*, but in his last paper that reference is considered erroneous. After a careful examination of the type and a detailed comparison with *Omomys*, I am fully convinced that it is the Uinta representative of this

genus, and is therefore the only Primate thus far known from the Uppermost Eocene of North America.

Its relationship is at once seen in the elevated character of the crown of the third premolar, as well as in the general agreement in the structure of the teeth. It is, however, the largest species of the genus known, and exhibits a marked advance in the structure of the teeth, in the more widely separated and distinct condition of the internal cusp of the fourth premolar, as well as in the absence of the anterior cusp of the trigon on the second molar. The Bridger species are all smaller and more primitive.

Hemiacodon gracilis Marsh.

Hemiacodon gracilis Marsh, this Journal, September, 1872, Separata, August 13, 1872, p. 21; *Omomys gracilis* Osborn, American Eocene Primates, Bull. Amer. Mus. Nat. Hist., June, 1902, p. 178.

This is one of the most abundant species of monkey in the Bridger formation, and as far as the specimens show is confined to the upper levels of the horizon. The type upon

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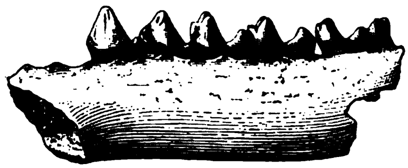

FIGURE 128.—Portion of right mandibular ramus of *Hemiacodon gracilis* Marsh; inside view; two and one-half times natural size. (Type of the genus and species.)

The elevation of the summit of the crown of the third premolar is greater in the type than in other specimens, on account of being partially out of the socket.

which Professor Marsh established the genus and species consists of a considerable part of a right mandibular ramus, figure 128, bearing the third and fourth premolars and the three molars in excellent preservation. The specimen also exhibits the alveoli for the second premolar, canine, and the two incisors, but is not sufficiently complete in front to admit of a determination of the number of incisors beyond all question. As compared with *Omomys Carteri*, the teeth of the lower jaw display in their structure a striking similarity to those of this species, and it is not at all surprising that Professor Marsh should have referred the two to the same genus. The chief differences consist in the enlargement of the first incisor and the reduced condition of the second incisor, canine, and second premolar, as well as in the better development of the internal cusp of the fourth premolar in *Hemiacodon gracilis*. The relations of the teeth in the front part of the jaw, I regard as

of more than specific importance, and these constitute in my estimation the main characters upon which the generic distinction rests.

In the molars the anterior cusp of the trigon is distinct in all, but least so in the last. There is likewise a very faint indication of a posterior median cusp in the heel of the first and second molars in the type, but in other specimens it is apparently absent. The posterior portion of the crown does not widen so rapidly as is the case in *Omomys Carteri*, the

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FIGURE 129.—Left lower jaw of *Hemiacodon gracilis* Marsh; external view; two and one-half times natural size; drawn from two specimens.

FIGURE 130.—Crown view of the same specimen.

In the drawing the alveolus of the first incisor does not appear as large as it actually is. The upper portion of the alveolus is broken away, so that only the bottom of the cavity is shown.

transverse diameter of the anterior and posterior moieties being more nearly equal. The fourth premolar is more advanced in structure than the corresponding tooth of *O. Carteri*. The third premolar in the type shows no trace of an internal cusp, but in some other specimens in the collection, of which forty or fifty individuals are represented, there is a distinct rudiment of this structure to be seen.

The second premolar and canine, figures 129 and 130, are preserved in several specimens, and their reduced size, as compared with the third premolar and the corresponding teeth of *O. Carteri*, is very evident. The incisors are not preserved in any specimen in the collection, but in several the front part of the jaw is sufficiently complete and well preserved to permit the alveoli to be made out with certainty. From these the number is shown to be two, of which the first is considerably larger than the second. The teeth were implanted in an uninterrupted

series and there is good evidence that the incisors were not very procumbent in position. The two halves of the lower jaw were not coössified, even in the most aged individuals.

In the upper jaw, figure 131, the teeth occur, in many examples, in association with those of the lower series. The structure of the molars is distinctive, not only by reason of the rather sharply quadrate outline of their crowns, but also because of their relatively great transverse extension. The first and second are subequal in size, and the third is considerably

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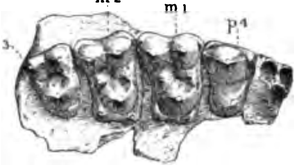

FIGURE 131.—Superior molars and fourth premolar of *Hemiacodon gracilis* Marsh; crown view; two and one-half times natural size.

The representation of the forward extension of the internal cingulum of the molars, as well as the size of the internal cingular cusp, is somewhat exaggerated.

reduced. The external cusps are moderately flattened upon their outer side, especially the posterior one, and they are bordered externally by a strong basal cingulum. The intermediates are unusually well developed, and there is a large internal pyramidal cusp. A small postero-internal cusp is developed from the cingulum, which continues forward around the inner side of the crown, and gives rise to a moderately strong subsidiary internal cusp. The extent to which this cusp, as well as the forward extension of the cingulum, is developed, however, appears to vary in the different specimens; in some the cusp is very distinct, while in others it is scarcely visible. The fourth premolar has single external and internal cusps. The third and fourth premolars are implanted by three roots, two external and one internal. The teeth anterior to these are unknown with certainty. The enamel is finely rugose in both the upper and the lower teeth.

In the fragment of a maxillary here figured, the anterior limits of the malar can be easily made out. It is thus shown that it does not reach forward to the lachrymal, but leaves the maxillary a considerable share in the anterior boundary of the orbit, as in the monkeys. The rather small, single, infraorbital foramen is situated above and opposite the posterior edge of the third premolar, about in the same relative position as that of the squirrel monkey. The maxillary gives further evidence of proportionally large orbits, and if the superior dental formula was the same as that for the lower jaw, the muzzle must have been considerably abbreviated. The whole aspect is, in

fact, not only characteristically Primate, but one considerably advanced.

In one specimen the head of a humerus is associated with a fragment of a lower jaw, which is apparently the proper size for *Hemiacodon gracilis*. The character of this bone is distinctly Primate. Among the living forms, it bears a closer resemblance to the humerus of *Propithecus* and *Avahis* than to any other with which I have compared it. This is particularly evident in the relatively great development of the lesser tuberosity and its inward and backward projection from the articular head. In this respect it also resembles the humerus of *Tarsius*, *Hapale*, and *Cebus*, although not so closely as it does that of the genera above mentioned. The large size of the lesser tuberosity is likewise a conspicuous feature of the humerus of *Limnotherium*, from which it may be concluded that it is a primitive character.

Professor Marsh has given the following measurements of the type:

Longitudinal extent of the nine lower teeth	20·5 mm
Extent of premolar and molar series	17·2
Extent of true molars	11·0
Antero-posterior diameter of last lower molar	4·0
Transverse diameter of last lower molar	2·4
Depth of jaw below last lower molar	6·3

The type specimen was found near Henry's Fork, by Mr. G. G. Lobdell, Jr. The other specimens of the collection are from the same horizon.

Hemiacodon pygmæus sp. nov.

A second species of this genus is indicated by a single superior molar, figure 132. Under ordinary circumstances, I should deprecate the proposal of a new specific name upon such an incomplete specimen, but in the present instance the relationship is so clearly indicated and the differences are so patent, that I do not hesitate to follow this otherwise reprehensible practice.

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FIGURE 132.—Superior molar of *Hemiacodon pygmæus* Wortman; crown view; four and one-third times natural size. (Type.)

The tooth in question displays its undoubted affinities with the molars of *Hemiacodon gracilis*, in its quadrate outline, its relatively great transverse extension, and the general arrangement of the cusps. The external cusps are somewhat more conical than those of *H. gracilis*, but the intermediate and internal cusps are practically the same as in that species. The great difference is seen in the size, *H. pygmæus* being but little more than one-half as large as *H.*

gracilis. It is possible that the tooth pertains to the small species described as *Omomys Ameghini*, but I do not think it likely.

The locality is not clearly indicated on the label, but the specimen was associated with other fragments from Dry Creek, which gives it an upper middle position in the Bridger horizon.

Euryacodon lepidus Marsh.

Euryacodon lepidus **Marsh, this Journal, August and September, 1872, p. 33, Separata.**

Professor Marsh in describing this genus and species says: "A small mammal, doubtless an insectivore, is represented by a fragment of an upper jaw containing the last two molars in perfect condition. Our collections contain other characteristic fossils which appear to be specifically identical with this specimen. The teeth preserved agree nearly in the composition of their crowns with the molars described by Dr. Leidy under the name *Palæacodon verus*, but each has its inner margin produced into a small tubercle. In the penultimate upper molar, this tubercle is especially prominent. The outer margin, also, of these molars has but a single faint indentation between the external cusps. Both teeth are surrounded by a distinct basal ridge. The specimens preserved indicate an animal about as large as a weasel."

Besides the type, there are in the collection four other examples which I refer to this species. One of these is a fragment of an upper jaw bearing the second and third molars, just as in the type; and three lower jaw fragments, which, however, in no instance are associated with the upper molars. The reference of the latter to this species, therefore, contains an element of uncertainty.

The upper molars, figure 133, resemble those of *Omomys Carteri*. In the second molar of this latter species, however, figure 123, the anterior internal cingular cusp is not developed, while in *Euryacodon lepidus* it is strong. The last molar, moreover, in the latter species is a little less reduced and the crown is not so narrow and pointed, especially on its internal or lingual side. The external cusps are rather conical, and the intermediates are moderately well developed. The homologue of the main postero-internal cusp has a somewhat more external position, and this portion of the crown has a distinctly less rectangular outline than the corresponding tooth in *Omomys Carteri*.

In the lower jaw, figure 134 (if the specimens are correctly referred to this species), the molars only are known. The structure of their crowns is quite different from that of any species of *Omomys*. The anterior cusp of the trigon is well

developed in the first molar, and has nearly the same relations as in the corresponding tooth of *Omomys Carteri.* In the second molar, however, this cusp has a much more posterior position and is decidedly smaller, while in the third it is completely absent. The last molar is narrower and more reduced than in *Omomys*, and the heel lacks the distinct pointed cusps seen in all the species of that genus. The crowns of the upper molars, especially that of the second, are almost as wide in front as behind, being in marked contrast with the molar

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FIGURE 133.—Two superior molars of *Euryacodon lepidus* Marsh; crown view; a little less than four times natural size. (Type of genus and species.)
FIGURE 134.—Lower jaw fragment of *Euryacodon lepidus* Marsh; side and crown views; two and one-half times natural size.

crowns of the species of *Omomys*. Thus it will be seen that the lower molars of *Euryacodon* are more advanced than those of *Omomys*, and there can be apparently very little doubt that they represent distinct genera.

The complete dentition of the lower jaw is unknown, and I have provisionally referred the genus to the Omomyinæ. A comparison with the type of Cope's *Anaptomorphus æmulus*, from the lower horizon of the Bridger beds, shows many points of similarity. As is well known, the type of this latter species consists of a lower jaw in which the first and second molars are present, but the third is missing from the specimen. In *Anaptomorphus* the anterior cusp of the trigon has disappeared in both the first and second molars, which at once establishes the fact that it is at least a different species from *Euryacodon lepidus* and the most advanced form of Primate thus far known from the American Eocene. It is upon this account that I have chosen to regard *Euryacodon* and *Anaptomorphus* as distinct from each other, until the full dentition of the former and the upper teeth of the latter are more fully known. If *Euryacodon* is eventually found to possess only two premolars in the lower jaw, it will then probably be necessary to unite the two genera under the name *Euryacodon*, since the latter has distinct priority over *Anaptomorphus*.

[To be continued.]

ART. XI. — *The Structure of the Piedmont Plateau as shown in Maryland;* by EDWARD BENNETT MATHEWS. (With Plate X.)

THE structure of the more or less metamorphosed sedimentary and igneous rocks exposed in the Piedmont Plateau, lying between the Blue Ridge on the west and the Coastal Plain on the east along the Middle Atlantic coast from New York southward, is a geological problem of wide interest to American geologists and has occasioned more or less discussion among various investigators who have worked upon it.

Throughout the Piedmont region are exposed numerous highly-crystalline gneisses and schists intermingled with crystalline limestones, quartzites, and phyllites which have been intruded by large and small igneous masses of granite, gabbro, serpentine, and volcanic rocks; all of which have been metamorphosed in varying degree up to the point where they have lost all evidence of their original condition.

The deciphering of the various formations occurring within the Piedmont is still in progress and many areas are yet unstudied, but the areal distribution of the various formations throughout the region north of Virginia has been determined with sufficient accuracy to indicate the various types of rock present. The areas about Washington, Philadelphia, and a large portion of the intervening country within the limits of the State of Maryland, have been studied in detail until it seems that some clue has been gained regarding the broad structural features and geological relationship of this complicated region. In the present paper it is proposed to give a tentative interpretation of the broader structural features as shown in Maryland by the detailed mapping of the author and his assistants during the last seven years. The basis of work* includes a reconnaissance of the entire Maryland Piedmont and the detailed mapping of approximately 1250 square miles lying north and east of Baltimore.

General Characteristics of the Piedmont.

The crystalline rocks of the Piedmont Plateau are well exposed in the area about New York, where they have been

* While the work in Maryland has been in progress, the author has had many office and field conferences with Dr. Bascom, who has generously allowed him to examine and to use her detailed manuscript maps of the Philadelphia area. The work in Maryland has been conducted independently at the same time and both investigators have been led to similar results for their special regions. The application of their common interpretation to the whole area of the Eastern Piedmont is here first issued by the author, who wishes to acknowledge the assistance received from his knowledge of Dr. Bascom's results which have most generously been placed at his disposal.

studied by Dr. F. J. H. Merrill* and his colleagues. Southward from the New York area the older crystalline rocks of the Piedmont are covered by the formations of the Jura-trias and do not appear again until in the vicinity of Trenton, whence they pass southwestward across Pennsylvania into Maryland, offering numerous good exposures along the banks of the Delaware, Schuylkill, and Brandywine, where they have been investigated by members of the Pennsylvania Survey and more recently in great detail by Dr. Bascom. Within the limits of Maryland the Piedmont crystallines are trenched by the Susquehanna, Gunpowder, Patapsco, Patuxent, and Potomac rivers and their tributaries. Beyond the Potomac, the same formations are continued southward through Virginia, North and South Carolina, Georgia and Alabama, where they have been examined by members of the different State surveys and by Mr. Arthur Keith of the U. S. Geological Survey.

In each of the areas studied, about New York, Philadelphia, Baltimore, and Washington, similar series of rocks have been found but the interpretation of their relationship has varied somewhat, and until recently no attempt has been made to determine the structure of the territory. The following table represents the lithologic types recognized in the different regions by the various authors.

From the following table it is easily seen that four distinct types of rocks have been recognized in each of the areas, though not always represented on the maps accompanying the verbal description. These are (1) a banded gneiss, (2) a thin-bedded or arkosic quartzite, (3) a marble, and (4) a series of mica schists.

Banded Gneiss.—In each of the areas is a highly crystalline gneiss composed of quartz, feldspar and mica with accessory minerals so distributed as to produce a well-marked gray banded gneiss, the individual bands of which vary from a fraction of an inch upward, the average thickness, however, being quite small. Some of these beds are highly quartzose resembling a micaceous quartzite, others are rich in biotite or hornblende producing dark to black bands indistinguishable in a hand specimen from mica and hornblende schists and gneisses derived from igneous rocks by metamorphism. Through these banded gneisses are intruded pegmatite and aplitic dikes more or less parallel to the regular banding of the gneiss. In all of the areas these beds are found highly inclined in their banding, which represents original variation in composition of the sediments or the igneous rocks from which they were formed. Some authors have regarded these as sedimentary, some as

*N. Y. Folio, Geologic Atlas of the United States, Folio No. 83, Washington, 1902.

TABLE SHOWING CORRELATION OF CRYSTALLINES IN EASTERN PIEDMONT.

Red sandstones and shales of the Jura-trias on the west and unconsolidated Coastal Plain Deposits of Jurassic-Recent age on the east; separated from the underlying rocks by a marked unconformity.

	New York area.	Philadelphia area.	Maryland area.		Washington area.
	Merrill.	Dr. Bascom.*	Williams.	Mathews.	Keith.
Silurian	Hudson schist, mica schist with garnet, staurolite, fibrolite, cyanite	Hudson mica schist and Wissahickon mica gneiss	Peach bottom slates Phyllite mica-schist muscovite-gneiss (in part)	Peach bottom slates Cardiff quartz conglomerate. Wissahickon mica schist including phyllite member at top	
Cambro-Ordovician	Stockbridge limestone.	Chester Valley limestone	Dolomite or marble	Cockeyville marble	
Cambrian	Poughquag quartzite, thin-bedded white to brownish carrying tourmaline and muscovite	Valley Forge and Edge Hill quartzite	Setters quartzite	Setters quartzite	
Pre-Cambrian	Fordham gneiss, gray banded, potash, feldspar, quartz, mica, hornblende	Arrowmink arkosic gneiss	Biotite gneiss muscovite gneiss (in part)	Baltimore gneiss	Carolina gneiss (in part)

* Dr. Bascom has furnished the following correlation of formations as recognized by different investigators in the Philadelphia area:

Rogers.	*Hall.*	*Bascom.*
Talcose and micaceous slate (middle member of Primal series)	Quartzose slate and mica schists (Rand's hydro-mica schists)	Hudson mica schists and
First and second gneissic belts	Chestnut Hill garnetiferous schists Manayunk mica-schists Philadelphia schists and gneisses (in part)	Wissahickon mica-gneiss (Hudson age)
Auroral limestone	Limestone, No. II	Chester Valley limestone (Cambro-Ordovician age)
Primal sandstone	Potsdam, No. I	Valley Forge and Edge Hill quartzite (Lower Cambrian)
Third gneiss belt	Eozoic or Azoic or Laurentian gneiss (in part)	Arrowmink arkosic gneiss (Pre-Cambrian)

This is exclusive of igneous material. The Overbrook porphyritic granite-gneiss is included in Hall's Philadelphia gneisses and the great gabbro

igneous, some as sedimentary masses intruded by igneous rock to form so-called injection gneisses. All have agreed that these banded gneisses are probably pre-Cambrian in age whatever their origin. Usually in eastern Maryland they are separated from other metamorphosed sedimentary rocks by igneous masses, but in the vicinity of Baltimore and in the Philadelphia area, as shown by Dr. Bascom, these banded gneisses immediately underlie the quartzite.

The Quartzite.—The quartzite is a fine-grained, somewhat saccharoidal, thin-bedded quartzite of white-brown color. The beds are usually separated by thin films of muscovite in small sparkling flakes. On the surface of these mica-covered cleavage or bedding planes frequently occur black tourmaline crystals which occasionally show evidence of movement along these planes. Individual specimens of the quartzite when massive may appear like the quartzose layers of the banded gneiss, but usually the rock is easily distinguished in the field. It generally is found dipping at a rather steep angle and because of its resistance to weathering is often a topographic feature of the region. This is a relatively thin formation which varies much in thickness from one to several hundred feet. Where this quartzite has been studied in anticlines and synclines, both normal and overturned, it appears to be younger than the banded gneiss and older than the neighboring marble.

The Marble.—The marble is a coarse-grained to medium-grained impure dolomite in which the impurities have been entirely recrystallized into silicates such as diopside, tremolite, phlogopite, etc. It is almost always a dolomite in chemical composition but may vary occasionally to a pure calcite rock. The bedding in these rocks is not easily recognized, but it is probable that the lines of impurity now represented by silicates indicate original differences in the sedimentary deposits. The amount of such impurities causes the rock to vary widely from a pure carbonate to one so rich in silicates that it may easily be mistaken for a gneiss until tested for hardness or with acid. These beds in the marble show considerable variation in the steepness of their dip, ranging from 10° up to 70° and occasionally they are found in overturned anticlines and synclines. The thickness of the formation is very variable and practically indeterminate on account of the paucity of exposures. Its presence is usually indicated by valleys along the sides of the quartzite ridges and its thickness apparently varies from nothing up to more than 2000 feet. No fossils have been found in the highly crystalline marbles and it is improbable that if originally present they could have withstood the changes which this rock has undergone.* The formation, however, has been traced

* A few deformed chert nodules have been found and they may yield microscopic forms on closer examination.

at several points into less metamorphosed rocks of similar composition where rocks of Upper Cambrian and Lower Silurian age have been found. Thus, it has been correlated with the Stockbridge limestone of western New England, the Chester Valley limestone of Pennsylvania, and tentatively with the Shenandoah limestones of Maryland and Virginia though no stratigraphic continuity has been established with the latter.

The Mica-Schists.—The mica-schist is composed of a series of highly micaceous, very schistose, and often crinkled aggregates of quartz, more or less decomposed biotite and garnet, with accessory orthoclase, cyanite, staurolite, fibrolite, etc. With the increase in feldspar the rock becomes a gneiss but is not as distinctly banded as the banded gneiss already referred to. The formation is chiefly characterized by the high content of mica, garnets, and occasional metamorphic minerals, and the small amounts of feldspar. The soils developed from the decomposition of the mica-schists are usually marked by an abundance of mica and rounded garnets. Beds of this type are only indistinctly marked and are separated with difficulty from the cleavage lines which may nearly parallel them. The entire formation has been much folded and it is not possible to make accurate determinations of the thickness. At first sight it would appear to be miles in thickness but in reality is probably not far from 2000 feet. The age of the rocks included under this term is not determinable by fossils carried by them, but, as in the case of the marbles, these schists have been correlated with less metamorphosed representatives which carry a fauna of Hudson River age.

The variation in the character of the marble through increased impurities causes the contact between the overlying mica-schist and the limestone to be one of gradation at times, and occasionally there seems to be a layer of more argillaceous mica-schists lying between the underlying quartzite and the well-defined marble.

Igneous Rocks.—Throughout the Piedmont area under discussion have been recognized numerous igneous rocks, now more or less metamorphosed, which are apparently intruded into all of the rocks as old as the mica-schists. Among the types found are granites and granite-gneisses, diorites and meta-diorites, gabbros and meta-gabbros, peridotites, pyroxenites and serpentines, meta-rhyolites, and meta-basalts. The contacts between these various masses are seldom exposed and the relative age of the various intrusions cannot be determined with entire satisfaction. So far as is known, the facts accord with the commonly accepted view that they represent in a large way a single period of igneous activity which no doubt extended over a considerable period of time. Just when these sheets

and larger intrusive bodies were thrust into their present position is not known, but the views most generally held at the present time indicate that the intrusion took place in post-Silurian time prior to the earth movements which produced the Appalachian Mountains. Earlier investigators and some at the present time express the opinion that this igneous activity was contemporaneous with the formation of the earliest rocks.

Metamorphism.—The older rocks of the Piedmont, as recognized by all investigators, have suffered more or less recrystallization and textural modification since their formation. This metamorphism has not been uniformly distributed over the entire region but, as emphasized by Williams, is much accentuated in the eastern portion of the Maryland area, where the rocks are thoroughly recrystallized and often lack in great measure their original texture. The original muds and sands of the sedimentaries have been changed to micaceous schists, gneisses, and quartzites and the various igneous rocks have been greatly modified in texture and occasionally in mineralogical composition. The textural change which is most evident is a marked development of schistosity which is to be noticed in all of the rock types already described. The change from massive to schistose rocks has not been uniform over the entire district or even over the more metamorphosed eastern section, but seems to be locally accentuated along lines which probably indicate zones of greater dynamic action.

The schistosity developed in the rocks of the Piedmont partakes of the general northeast-southwest trend of the province and varies in dip sometimes to the eastward and sometimes to the westward. It is present in both the sedimentary and igneous rocks. In the latter, it is sometimes so strongly developed that the resulting rocks in small areas present the appearance of metamorphosed sediments, although one may find all gradations between the unaltered massive types and the equivalent fissile schists. In the sedimentary rocks the schistosity is developed to a degree which greatly obscures the original bedding and oftentimes renders the determination of bedding planes impossible.

The development of schistosity is accompanied by a recrystallization of the affected rocks, which may simply result in a new development of the mineral species found in the original rock or in a molecular rearrangement producing many new minerals. Thus the gneisses are composed of recrystallized quartz, feldspar, and mica material, while the feldspars of some of the granites, the meta-rhyolites, gabbros, and diorites have been changed to epidote and the pyroxenes to fibrous or compact hornblende. The new minerals usually lie with their longer axes parallel to the planes of schistosity. In the case

of the phyllites and mica-schists the original material has been changed to muscovite, chlorite, and quartz with accessory minerals such as garnet, staurolite, cyanite, etc.

Structure of the Maryland Piedmont.

The four types of metamorphosed rocks with their accompanying igneous types unite in the Piedmont area of Maryland to form a complex geological mass in which the structure of the region is very greatly obscured by the metamorphism, secondary schistosity, and recrystallization. The problem is still further complicated by the presence of several series of minor folds which obscure the larger structural features of the region. The centering of attention on these minor structural features rather than on the broader elements of structure have led previous students of the area to divergent interpretation, or despair at ever reaching a true solution.

Previous Interpretations.—The Piedmont Plateau of Maryland has been studied by many investigators and the interpretations which they have given to the area may be classified, as suggested by Williams, into three categories, involving differences in age in the sedimentaries of the eastern and western portions of the area or differences in the structural elements which have brought the rocks to their present position. The three hypotheses as outlined by Professor Williams* are:

"1. That the rocks of both the eastern and western areas are of the same age, and that they have been bent into a broad syncline whose flanks are so sharply folded, faulted and thrust as to simulate the fan-structure observed in high mountain chains; and that the eastern flank of this synclinal or fan was much more highly metamorphosed than the western both by more intense dynamic action and by intrusion of a great amount of eruptive material.

2. That the more highly crystalline eastern area is greatly older than the western schists, and served as a rigid buttress against which these were thrust and folded.

3. That the eastern area is composed of rocks far more ancient than the western, which extend out under these, forming the floor upon which they were deposited; and that although already much folded and metamorphosed, this crystalline floor underwent at least one more folding after the schists had been laid down, carrying these with it and involving them in a considerable but not an extreme amount of disturbance and metamorphism."

The first of these hypotheses was that held by Tyson, who was State Agricultural Chemist from 1853 to 1862, and who published the first complete geological map of Maryland in

* Bull. Geol. Soc. Amer., vol. ii, p. 315.

1859. According to this view the structure is a more or less deformed synclinorium. This hypothesis, together with the second, is regarded as untenable by Williams on the grounds enumerated in his paper on the subject, where he proposed the third hypothesis as the most reasonable explanation of the facts and the one to be accepted as most probable unless subsequent explorations should render its modification necessary.

At the time Williams proposed this hypothesis no part of the Maryland Piedmont had been mapped by the U. S. Geological Survey, and the maps at his disposal consisted of inaccurate road maps of the various counties. At this time also the detailed mapping of the Piedmont, which was later prosecuted by him with success, had not been pursued beyond the immediate vicinity of Baltimore, where the structure is somewhat exceptional. The conclusions drawn were based upon several driving trips across the Piedmont Plateau in different directions, and the generalizations reached, while brilliant for the amount of information in his possession, are such as to demand modifications as the detailed mapping of the Piedmont on the scale of a mile to the inch by the Maryland Geological Survey progresses.

Results of Later Work.—Shortly after the publication by Williams of the paper referred to, the writer commenced a mapping of local areas under the former's direction and has continued field investigations as opportunity presented during the twelve years, until fully 1200 square miles of the Piedmont have been mapped on the scale of 1 : 62,500 and the entire Piedmont has been visited in economic work demanding greater or less local detail. The work of deciphering the structure of the Piedmont of Maryland is by no means ended, but it is proposed to give in the following pages what are believed to be the general lines of structural uplift and depression across the area. Many local questions still remain unsolved and much detailed mapping is still necessary in the western portion of the Plateau, but the views here expressed have been found to present the most reasonable interpretation of the area studied. Moreover, while they have been developed independently they are found on comparison to be more or less in accord with the structural interpretations resulting from the most recent work in corresponding areas to the north and south.

The methods employed in the investigation of the Piedmont geology embrace a consideration of all of the data available under the conditions encountered. The region considered lies south of the zone covered by the continental ice, and as a consequence few exposures of fresh rock are encountered except in the recent stream cuttings or in artificial openings. At the same time, bowlders and disintegration products found on the

surface are usually indicative of the character of the underlying rock. Throughout most of the area, especially in the little-dissected remnants of the old peneplane, the disintegration has extended from one to twenty or thirty feet, according to the character of the rock, and one may find entirely disintegrated masses of clay or sand retaining the original textures of the parent rock. Even much of the material which at first is so hard as to require blasting, breaks down when exposed for some time to the influence of the atmosphere. Disintegration of this type leaves few exposures and renders microscopic studies of many apparently fresh specimens unsatisfactory, but in turn facilitates the areal mapping since the soils and minor features of the disintegrated products are often characteristic of the underlying rock. The plant cover is also occasionally distinctive since certain forms of plant life are found limited to the areas underlain by certain rock types or there possess certain peculiarities of development.

The lack of fresh exposures and the detailed complexity produced by the schistosity and minor plications make it exceedingly difficult to determine the true bedding plane, and this is not possible in many instances. It becomes necessary therefore, to lay relatively less stress on the structural features found in single small exposures and to assign greater importance to the areal distribution and the general structural features determined by it.

Fossils have been found in only one or two areas, where they are much distorted or damaged and there is little hope that other deposits of better preserved forms will be found; for only the most hardy forms could withstand the metamorphic changes which the rocks have undergone.

The types of structure encountered in the region are joints, normal faults (usually of small throw), folds and probable unconformities. The *jointing* is usually in three fairly well-defined series of joints which cause the rock to break into irregular rhomboids. When well exposed in the banded-gneisses of the Baltimore and other areas, they show little or no movements along their planes although now and then a displacement of a few inches may be found along fault planes which are more or less parallel to the planes of jointing. The *faulting*, if present, is usually obscured by the homogeneous character of the rocks and the lack of well-defined bedding in many of the sedimentary masses where the faulting is exposed. It is accordingly impossible to trace the faults beyond the exposures in which they are found. So far as examined the throw of these faults is slight, ranging from a few inches up to a foot or two, and the general faulting structure partakes of that characteristic for the Jura-triassic beds which overlie the Piedmont on

its western border. Large overthrust faults may perhaps occur in the region, obscured by the similarity of deposits and the vegetation, but no evidence up to the present time has been found warranting the assumption of such overthrust faults unless, perhaps, in the region a few miles west of the Northern Central Railway, at a point twenty-five miles north of Baltimore. If such a fault occurs here, the plane of the overthrust must be very flat and the extent of the thrust small, since the areal distribution of the phyllites to the north and the gneisses to the south show no appreciable break in their boundaries. It seems more probable to the author that the recurrence of the marble in a series of parallel bands is due to folding or minor faulting than to an overthrust.

The *folding* in the rocks of the area is of three types: minute crinkling, small unsymmetrical wavy folds, and broad Appa-

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lachian ones in which the adjustment appears to have taken place along the bedding. The accompanying figure indicates the differences as sketched from exposures in the field. The intricacy of the minor folds has been the feature usually noticed by earlier investigators, who have many times overlooked the gentler open folding of the larger folds. In the succeeding discussion the emphasis will be laid upon these larger folds and less attention will be drawn to the minor ones, since the broader rather than the detailed local structure of the Maryland Piedmont is the problem under discussion.

The dip observations made on small exposures often relate to the minor folding and are usually quite steep, ranging from 40° to 80° with an average of 55° in the exposures. These dips are usually considerably at variance within short distances, although there seems to be a tendency for the exposures to be formed on those portions of the minor folds where their dip is in the same direction as that of the major fold, the return dips being usually concealed. The earlier structural interpretations have been based for the most part, in Maryland at least, on the dips of these secondary folds, and it has accordingly been customary to regard the region as one of steep monoclinal or closely compressed overturned folding. The dips of

the major folds, as determined by tracing individual beds with their sinuosities across the larger exposures, are much flatter than those of the minor folds, usually ranging in value from 5° to 40° with an average of between 25° and 30°. In many instances it is not possible to determine this major dip, but the areal distribution of the rocks is generally found to be in harmony with such observations as can be made.

Overturned folds are occasionally encountered, the best example so far studied occurring just west of the Baltimore-Harford county boundary line, about five to ten miles south of the phyllite boundary. The structure here is well marked by the occurrence of a quartzite, an intermittent marble, and the mica-gneisses surrounding a core of banded mica- and hornblende-gneisses. Contrary to the usual interpretation, this large fold is overturned to the southeast, causing all the dips to slope to the west.

Unconformities apparently occur in the crystalline rocks of the Piedmont, especially at the base of the quartzite and the top of the marble, but it is very difficult to determine whether or not the latter is due to a change in the character of the original limestone which, when highly argillaceous, is metamorphosed into a calcareous gneiss or mica-schist which is practically indistinguishable by field observation from the adjoining rocks. The points where this unconformity has been supposed lie near the limits of the area in which marble occurs, and it seems highly probable that the conditions of the formation of a limestone became less favorable around the limits of the area, and that through gradation the limestones pass off into rocks which, when metamorphosed, are indistinguishable from the overlying mica-schists.

Geological Sequence.—The field work conducted by the author and his associates on the Maryland Geological Survey indicates that in the Maryland Piedmont we have the following series of metamorphosed rocks which were apparently of sedimentary origin.

Peach Bottom slates Cardiff quartzite	Silurian (?)
Wissahickon phyllite, mica-schist and mica-gneiss	Ordovician
Cockeysville marble	Cambro-Ordovician
Chickies quartzite or Setters quartz schist	Lower Cambrian
Baltimore gneiss	Pre-Cambrian

The determination of the age of these formations by fossils s impossible at the present time in Maryland, and the age ssigned the various beds is therefore regarded as somewhat

unproven, but, as already outlined in the first part of this paper, the sequence here is comparable to that of the similarly situated areas farther north where they have been correlated with less metamorphosed beds bearing fossils. The lithological features and structural characteristics are the same in the different regions and it is probable that this correlation is the true one and that it must, perhaps forever, remain unproven for certain portions of the Maryland region where the beds are separated from other sedimentaries by igneous rocks. As the work now in progress under the joint auspices of the Maryland and U. S. Geological Survey goes forward, it may be possible to correlate on structural grounds the limestones with fossil-bearing beds near Frederick, and it is possible that well-preserved fossils may be found in the less metamorphosed sedimentaries of the Frederick valley to the west of Parr's Ridge, as Mr. Keith has already detected fragments in this region.

Igneous Rocks.—Through these sedimentary rocks have been intruded large masses of igneous material which have consolidated into granites, gabbros, and other igneous types. Formerly it was regarded that the masses were intruded in pre-Cambrian time and that they were contemporaneous with the metamorphism of the crystallines. This cannot be wholly the case if the foregoing interpretation of the age of the sediments is correct, since these igneous rocks are intruded into the rocks here considered of Silurian age.

The areal distribution of the formations enumerated above is given in the accompanying map (Plate X) which has been compiled from the published maps of the New York and Pennsylvania state surveys; from the New York and Washington folios of the U. S. Geological Survey; and the manuscript maps of Dr. Bascom and the writer. The scale of the map has required more or less distortion in the representation of the quartzite and limestones and in the mapping of the rocks of the less metamorphosed western portion of the plateau. The lines must therefore be regarded as only provisional, especially in the areas north of Washington and that part of Pennsylvania which has not been mapped by Dr. Bascom.

General Structural Lines.

The broad structure lines of the Maryland Piedmont, so far as they have been worked out in the eastern or more crystalline portion, are indicated in the accompanying sketch by lines occupying the axes of the synclines and anticlines. It is impossible on any small scale map to represent the minor structural lines, which of course more or less modify the position of the axes of the major folds. It is believed, however,

that the lines here indicated represent the structural characteristics up to the scale of the base employed. The individual axes distinguished in the area are described in greater detail in the following discussion.

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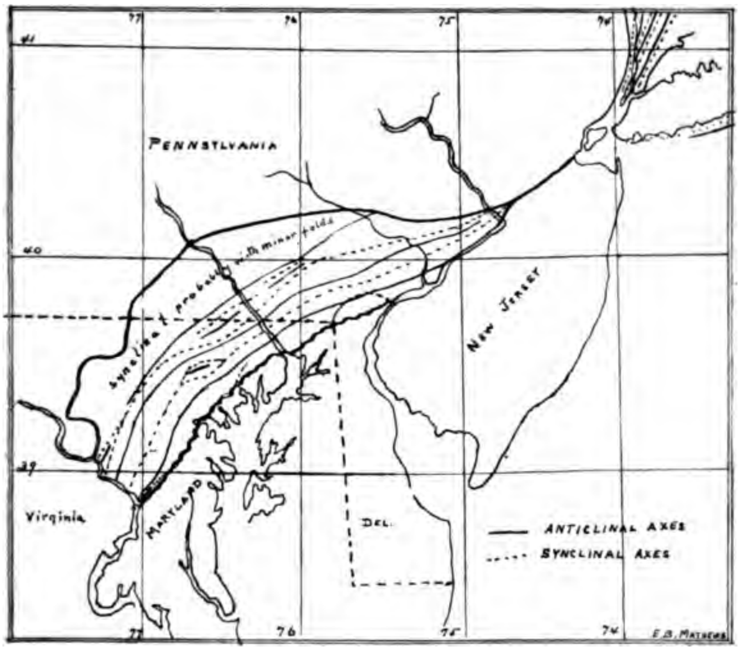


*Structure Lines of the Piedmont.**

East Alexandria- Winters Run Syncline.—Poorly exposed syncline extending from Churchville to east of Baltimore, east of Washington to Alexandria. Covered for the most part with Coastal Plain deposits and largely hypothetical. As shown in Harford county, this axis is plunging southwest.

Washington Uplift-Towson-Belair Anticline—A rather shallow anticlinal axis which may in reality be composed of several minor ones, recognized by Keith as a portion of his West Washington anticlinorium. Occupied for the most part by gabbro sheets on either flank. Probably the line passing from the vicinity of Belair eastward through the central Piedmont district of Cecil county and possibly corresponding to the eastern anticlinal axis suggested by the older gneiss of the Philadelphia

* When the terms "anticlinal axis" and "synclinal axis" are used it is not intended to convey the idea that the lines are of simple structural folds but that these lines represent the dominant axes of anticlinoria and synclinoria. For local points see maps of National and State Geological Surveys.

area. Apparently plunging to the northeast, but this is not clear. These two axes lie within the limits of what are regarded as possibly Archean gneiss areas.

Caves–Forest Hill Syncline.—A well-defined synclinorium extending southward from Scarboro to the area between Green Spring and Worthington valleys in the Baltimore quadrangle. Plunging to the southwest. At the Caves the center of this synclinorium is occupied by a small anticline which brings the limestone to the surface. Southward from the Caves the axis apparently extends to the Clarksville–Highlandtown region and probably corresponds to the sag between the two lines of uplift in Keith's anticlinorium. The synclinal basin east of Buck's Ridge, Pennsylvania, may represent a continuation of this general line.

Cabin John–Jarrettsville–Bucks Ridge Anticline.—An overturned anticline beginning west of Jarrettsville on the Taylor Valley road and extending southwestward through Manor and Western Run on the Parkton quadrangle; is probably part of the general anticlinal axis which is represented to the southwest by the imperfectly studied axial line determined in great measure by the strong synclines on either side. It is approximately in the same position as the strong uplift recognized by Keith near Cabin John on the West Washington quadrangle. Eastward from Jarrettsville the anticlinal axis is less marked and is apparently occupied by the long band of serpentine which crosses the Susquehanna river at Bald Friar and extends eastward into Pennsylvania, where it is represented by the Bucks Ridge anticline.

Glencoe Syncline.—A small synclinal axis extending from Glencoe on the Northern Central Railroad southwest through Priceville to Mantua on the Parkton quadrangle and apparently separating the lines of the anticlinal axes on either side, bringing to the surface along Western Run some of the overlying limestone. The structure in this region has not been thoroughly worked out and there may be a small thrust fault.

Cardiff Syncline.—A strongly-marked synclinal basin with its greatest depth in the neighborhood of Cardiff, Maryland. This conforms to the center of the phyllite belt as far as that has been traced. It apparently connects with the synclinal axis recognized by Keith as passing just east of Great Falls. This syncline carries the youngest rocks of this portion of the Piedmont Plateau and has been recognized as a structural feature for many years by the Pennsylvania and Maryland geologists. The bedding in this basin is no more distinct than in the basins and folds previously described, but the presence of the small quartz conglomerate at the base of the slates as well as the slates themselves have made the recognition of its presence

much easier. It seems to be a southern extension of the Chester Valley folding,

Tocquan Anticline.—Tocquan anticline, recognized by Professor Frazer in his report on Lancaster county (CCC, p. 128) as a broad flat anticlinal arch somewhat tilted to the southeast, crosses the Susquehanna river at McCall's Ferry. This structural line has been traced by the Pennsylvania geologists from northern Chester county through Lancaster and York counties to the Maryland line. Throughout this area the axis is complicated by the presence of minor folds. It seems to rise to the north and south. In Maryland the work along this axis has not been carried very far, but the areal distribution of the rocks seems to indicate that it corresponds roughly with the center of the mica-schist zone passing east of Westminster, crossing the Potomac to the southwest of Rockville. The occurrence of interfolded phyllites along the western boundary of the more crystalline part of the plateau, as worked out by Keith, and of phyllites farther south to the west of Gaithersberg, suggests that this axis is here even less strongly marked and that it is broken into several shallow folds.

The region between this anticlinal axis and the overlapping Jura-trias bed on the west appears to be a shallow much-folded synclinorium with an anticlinal axis passing near Union Bridge, Maryland, but this region has not been worked with sufficient detail to warrant more definite statements.

On the eastern side of the Catoctin mountain the Shenandoah limestone rises with an easterly dip from beneath the phyllites and is in turn underlain by the Antietam quartzite and other rocks of Cambrian age.

Character and Distribution of the Igneous Rocks.

The most prominent feature of the igneous rocks is the occurrence of large masses of gabbro in more or less parallel bands, separated for the most part by masses of granite and smaller areas of ancient gneisses. The areal distribution of these gabbro masses, which in the region about West Chester, Pennsylvania, have been found by Dr. Bascom to extend across from one belt to the other, is believed by the author to indicate that the various occurrences represent what was once an immense gabbro sheet extending from Laurel, Maryland, to the Schuylkill river, a distance of fully 85 miles with an exposed breadth of at least 15 miles.

Through this great sheet of gabbro were apparently intruded the granites and later meta-rhyolites and pegmatites, the whole constituting one great series of igneous activity. When these intrusions began or when they ceased is not clearly determinable since contacts between the various rocks are almost

entirely lacking, and any contact metamorphism which they may have imposed upon the rocks existing at the time of their intrusion is now obscured by the subsequent metamorphism which they and the associated country rock have undergone. From the fact that parts of this igneous complex are intruded into the rocks regarded as Silurian in age, this activity could not have ceased prior to the later portion of the Silurian and may have been much later. That the intrusions are not younger than Paleozoic time seems to be an inference well supported by the fact that they along with the sediments partake of the broad folding characteristic of the Appalachian region to the westward, which was probably developed contemporaneously in the rocks of the eastern and western portions of the state. Moreover, the sedimentaries of Jura-trias time show little folding of this type, their deformation being due almost entirely to very gentle folds and small faults of slight throw.

Relation of the Eastern and Western Districts of the Piedmont

The division of the Piedmont Plateau into an eastern division composed of much metamorphosed, highly crystalline rocks, and a western division characterized by less metamorphosed, so-called semi-crystalline, rocks has long been recognized but was first sharply emphasized by the late Professor Williams in 1891. He regarded the eastern area as composed of rocks far more ancient than those in the western district and that they extended westward, forming a floor upon which the younger phyllites were deposited. He also believed that the eastern portion had already been much folded and metamorphosed before the phyllites had been laid down. As conclusive against the identity of age of the semi-crystalline and holocrystalline rocks he summarized the following points.*

a. The structure is not really a synclinal, but a fan-like divergence of dip from a central vertical axis, such as could not be produced by any synclinal bending in a continuous series of similar beds.

b. Any cause altering any part of an original series more than another would not make an *abrupt* contact, such as we find between the semi-crystalline and highly crystalline rocks of Maryland, but a gradual transition.

c. Any cause altering one flank of a synclinal more than the other would make the contact between the two kinds of rock and the axis of the synclinal coincide, as is not the case in Maryland.

d. The eruptive rocks of the eastern area are found in many places in close proximity to the slates or schists, without having effected their alteration; hence they are either not the cause of metamorphism, or they are themselves older than the semi-crystalline rocks; and, moreover, the sudden disappearance of the abundant eruptive rocks at the edge of the western area is itself a strong reason for supposing that it is of later age.

e. We cannot suppose that excessive dynamic action was the cause of the metamorphism, because where we should expect the folding force to have acted equally we find the hardest rocks (eruptives) much more altered, foliated, and disturbed than the soft argillites.

* Bull. Geol. Soc. Amer., vol. ii, 1891, p. 316.

The generalization reached by Williams in this paper is one of far-reaching importance and marked his ability to gain clean-cut conceptions of intricate problems from the most meager investigations. The writer has had occasion to re-examine most of the areas studied by Williams and has been impressed with the grasp of the subject and accuracy of the conclusions drawn when judged by the amount of information at his disposal. It should be borne in mind, however, that at the time this paper was written and even up to the date of Dr. Williams' death, only a small portion of the Piedmont in Maryland had been mapped by the topographers of the U. S. Geological Survey and not all of this had been studied in detail geologically. The generalizations drawn were based upon rapid reconnaissance driving-trips across the Plateau rather than upon detailed examinations carried on throughout the region.

Bearing these facts in mind, it is no serious criticism to Williams when the writer asserts that the detailed work of the last ten years, conducted with greater opportunities and with the aid of topographic maps, shows that the facts on which Williams based his conclusions are not proven. Taking up the five points regarded by him as conclusively proving that a time break exists between the eastern and western rocks, the writer would call attention to the fact that the "fan-like divergence of dip from a central vertical axis" does not seem to be a correct interpretation of the structural lines found within the region, which, on the contrary, indicate that there has been a series of folds rather than a single syncline or fan-like structure. The apparent occurrence of such a structure is due partly, no doubt, to the confusion of true bedding planes with those due to schistosity. The abrupt contact, such as Williams seemed to find between the semi-crystalline and highly crystalline rocks of the Piedmont, apparently does not exist with the sharpness formerly supposed, since Keith's work in Carroll and Howard counties has broken the sharp line drawn by Williams into an intricate series of intertonguing areas. The contact between the so-called phyllites and the gneiss as drawn by Williams is, in most cases, a contact between the phyllites and the mica-schists and gneisses of Hudson age rather than with the banded gneisses believed to represent pre-Cambrian. The contact here, judging from the experience of more recent workers in the region, is not abrupt but is usually obscured by the similarity of material or the likeness of soil resulting from the mica-schists and banded gneisses.

The fact that the igneous rocks of the eastern area when in close proximity to the slates or schists show little metamorphism, may be explained by the fact that within the Maryland

area only relatively small bodies of serpentine and granite come in contact with the younger gneisses and schists, and where such is the case the intrusive body has been so small as to produce no appreciable metamorphism. Moreover, if any contact metamorphism occurred, it would now be practically unobservable since the entire region has been more or less metamorphosed and contacts are almost entirely lacking in fresh rock. "The sudden disappearance of the abundant eruptive rocks at the edge of the western area," as inferred by Williams, is now recognized to be a conclusion not wholly in accord with the facts. Keith in his work in Frederick county found numerous bodies of aporhyolite and metamorphosed acid volcanics and this find has been corroborated and extended by the field work of the writer. In this region of so-called semi-crystalline rocks the eruptives found by Keith and others have been so metamorphosed into sericitic schists that they are scarcely distinguishable from the nearby phyllites except for the presence of small quartz and feldspar phenocrysts.

The points raised by Williams that the contact between the rocks of the eastern and western areas does not coincide with the axis of the syncline and that the eruptives were much metamorphosed at points where one would infer from the structure but little metamorphism, involve the assumption of a rather simple synclinal or fan-like structure which has already been shown to be discordant with the facts as developed by later and detailed investigations.

From the foregoing paragraphs it may be readily seen that the writer does not believe that the points raised by Williams validly disposed of the contemporaneous age of the rocks in the eastern and western portions of the Piedmont. Moreover, the detailed work of Keith on the west and the reconnaissance work by the Maryland Geological Survey on the north, point to an infolding of the various rocks which ultimately may show their similarity in age, when the detailed work has been completed.

Conclusions.

From the past ten years of work in the detailed mapping of the Piedmont rocks of northern Maryland the author has been led to the following conclusions as best in accord with the facts in hand:

1. The older rocks of the Piedmont consist of both sedimentary and igneous types which since their formation have been more or less metamorphosed.

2. The metamorphosed sediments include banded micaceous and hornblende gneisses of pre-Cambrian age; a more or less intermittent thin-bedded generally tourmaline-bearing quartz-

ite of Cambrian age; an intermittent dolomitic marble or magnesian limestone of Cambro-Ordovician age; and a series of mica-shists and the gneisses of Ordovician age. Above these occur a somewhat intermittent poorly developed quartzitic conglomerate and the Peach Bottom slates.

3. The igneous rocks consist of an immense gabbro sheet, intruded by numerous large bodies of granite and meta-rhyolite, and accompanied by numerous more basic serpentinized bodies. These various masses represent stages in a single extended period of igneous activity.

4. The time when this activity took place was later than early Silurian and earlier than the late Carboniferous; probably in the early part of this interval.

5. The chief structural features of the region are the metamorphism and constant schistosity and the broader folding of the different rocks.

6. The metamorphism of the rocks, especially of the banded gneisses, probably commenced prior to the intrusion of the gabbro and granite and was accentuated by them in the eastern portion of the Plateau.

7. The folding of the region is of the Appalachian type, the rocks occurring in several long, more or less parallel folds, with few faults and but occasional overturned folds.

8. The eastern and western areas are probably of the same age; differences in metamorphism being due to the large bodies of deep-seated intrusives on the east and the smaller bodies of surface volcanics on the west.

9. The sequence found in Maryland may be recognized from Washington to Trenton and in the region north of New York.

If these conclusions are confirmed by later investigation, it will be necessary to modify the generally accepted hypothesis of a former mountain range along the eastern Atlantic now represented by the Piedmont Plateau; or the location of this hypothetical range, which is supposed to have supplied the sediments for the Appalachian sea during Paleozoic time, must be shifted, at least for the earlier Paleozoic, farther east where its roots would not lie buried under Coastal Plain deposits.

Johns Hopkins University, November, 1903.

ART. XII.—*Direct Micrometric Measurement of Fog Particles*; by C. BARUS.

1. *Introductory.*—Before using the data computed for the dimensions of fog particles in the reductions of my observations of atmospheric nucleation,* it seemed expedient to endeavor to obtain corroborative values by some straightforward method. Aitken's dust counter had naturally suggested itself early in the course of my work; but the results so obtained are essentially indirect as the fog particles are not themselves observed. It was necessary, therefore, to devise apparatus by which the identical fog particles of a given corona could be directly entrapped and held for examination. This was eventually accomplished in a way admitting both of the measurement of the diameters of the particles and, probably, of counting the number precipitated under known conditions. Moreover, the particles caught, however fine (even less than $\cdot0003^{cm}$ in diameter), can be kept in place for observation, so that microscopic photography is applicable not only for the purpose of obtaining size but (possibly) number.

Many investigations are thus suggested, as, for instance, a repetition of Thomson's method for determining the charge of an ion; an experimental test of the subsidence equation for small spherules, etc. Again, while the corona gives merely the average size of the cloud particles, the microscope is particularly available for indicating variations of diameter for the particles of the same corona. In fact, the water particles when caught are not of a size; they are graded and hence the nuclei are probably also graded in size.

2. *Apparatus.*—Aitken's beautiful and highly ingenious instrument† is well adapted for the work for which it was designed; but it will not subserve the present purposes. Aitken's droplets evaporate too rapidly in spite of their artificially increased size. The need of mixing atmospheric air and dust-free air with shaking and stirring is an interference with the nucleation. In fact, water nuclei may even be generated in this way, possibly by the friction of air passing across damp surfaces. There is the tendency of the plate after long use to fog permanently or to collect droplets on its own account. Finally, it would be very difficult to remove the contents of the coronal chamber to the dust counter without changing the nucleation during the transfer.

I therefore endeavored to ascertain whether the particles

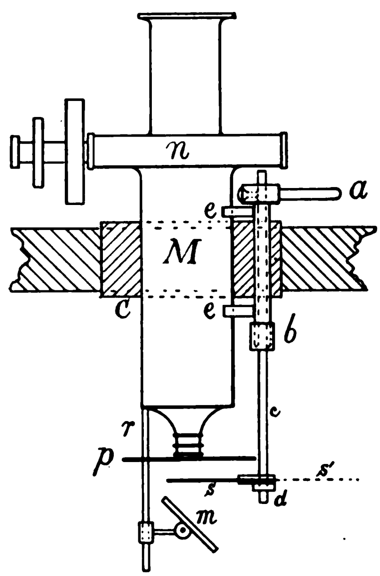
* Phys. Review, xvii, p. 233, 1903; cf. ibid., xvi, 193, 246, 1903.

† My thanks are due to Mr. A. L. Rotch, who was good enough to lend me his dust counter.

might not be made visible directly. The chances of success seemed small indeed, in particular as Assmann* had failed to see the particles with the magnifications of even 400 diameters. But after long trial, the result was eventually accomplished in a way that now seems surprisingly simple.

The compound microscope, *M*, magnifying about 100 diameters, is provided with a filar ocular micrometer, *n*. The objective and the whole lower part of the microscope is submerged in the condensation chamber, being suspended for this purpose from the wide rubber cork, *C*. All lenses below *C* are hermetically sealed with wax. The microscope originally carried a rigid stem, *r*, to which were then attached the plate, *s*, to be examined, the mirror *m*, and the metallic disc or shield, *d*. Afterwards the more flexible adjustment shown in the figure and described below was adopted. The lower side of *p*, which is flush with the objective, and the upper side of *s* are covered with wet blotting paper, the latter being perforated to admit light into the microscope through the thin cover glass placed at *s* and held sharply in focus by a suitable clip. The field within which drops are to be counted is bounded at pleasure by the wires of the micrometer.

1



This apparatus was totally unsuccessful. Drops were but rarely seen to fall on exhaustion, while the dew soon gathered on the plate *s*, in such a way as to be easily mistaken for droplets; for the dew evaporates like the latter when the microscope is removed, and the regularity of the pattern on the plate is the only distinguishing feature.

Various modifications of this apparatus were then used, among them capsule forms similar to Aitken's, but containing a very thin plate of glass or mica or celluloid slightly raised above the base on pellets of wax. It was supposed that this would counteract the tendency of the drops to vanish by evaporation from the warmer glass surface. Capillary metallic

* Cf. Arrhenius, Kosmische Physik, vol. ii, p. 487, 1903.

tubes led to the "curl" aneroid, the filter, and to the cock for influx of air, the only large tube being the exhaust pipe. Condensation again occurred as a microscopically granular deposit spontaneously on the raised surface, under all circumstances, and the experiments were failures. After oiling the raised filmy mica surface, however, droplets were often seen to fall and either to stick fast or to float. These could at times be counted (2000–5000 per cub. cm.); but the rapid evanescence of precipitated droplets and the failure of all attempts to reach systematic results induced me to abandon the capsule.

I therefore returned to the apparatus in figure 1, using at s a plate of thin microscopic glass covered with a film of oil and exposed in the capacious vacuum chamber. The experiments were now phenomenally successful. Thus for the aperture $s = 5$ the mean results were $n = 150{,}000$, and for $s = 4{\cdot}6$ (w g b p), $n = 140{,}000$. The precipitation of globules was clearly seen and they persisted even after the exhaustion was removed. The numbers being excessive and referable to globules swept in by lateral air currents, an improvement was now added by increasing the diameter of the disc p to about 5^{cm}. The improved apparatus gave no results whatever, and the mere addition of the wider disc wiped out all precipitation. But this capricious behavior is characteristic, for next day with a smaller disc drops were seen to fall as follows:

$s = 4{\cdot}5$	w g b p	$n = 6{\cdot}5 \times 10^4$
$4{\cdot}6$	w g b p	$4{\cdot}7$
$6{\cdot}3$	w g b p	$13{\cdot}3$

after which no precipitation could be caught in the six subsequent exhaustions by the identical method. The same unaccountable irregularity was noted in the afternoon. Next day again the first experiments showed

$s = 6{\cdot}0$	w c g	$n = 7{\cdot}3 \times 10^4$
$6{\cdot}4$	w g v p	$12{\cdot}4$

after which further precipitation did not occur.

The apparatus was then again modified to the final form shown in figure 1, by inserting a thin brass tube laterally through the stopper C, and firmly soldering this tube at e above and below to the body of the microscope. A rod snugly fitting the tube thus provided an eccentric focussing device, $abcd$, with a stuffing box at b, and an external handle at a. The latter is adjustable by aid of a set screw so that the plate s may be kept in focus during rotation of the rod. To catch the droplets, the plate s is rotated into the position s' quite beyond the shield, p, for a time (15–30 seconds) and then returned to s for examination. In this way the definite

results were obtained, in a manner to be further detailed below, with the apparatus free from capricious behavior. It is of particular interest that the particles caught on the oiled surface persist as brilliant round globules for a long time (10 min. or more) in a saturated atmosphere. They very gradually vanish as a rule, on the readmission of air into the condensation chamber.

To remove the globules for the next experiment the influx of air is thus not generally sufficient. It is necessary to withdraw the microscope from the condensation chamber bodily and to wave it about a few times in dry air. On returning it to the chamber the plate is then again clean and white.

At first the plate was oiled by a small flat piece of blotting paper saturated with oil and held on a stem, care being taken to remove all excess. Clean machine oil or ordinary illuminating oil, or a mixture of the two, subserved the purpose about equally well. Probably the best method of oiling consists in dipping the plate rotated outward to s' in very hot melted vaseline (to drive away moisture), removing the excess while hot by filter paper, and when cold submerging the plate in petroleum for transparency. With solution of vaseline in benzine, etc., I have been less successful.* A film of varnish dried and soaked in turpentine was used. When drops are to be counted by the method given below, the oil film must be practically solid; otherwise the capillary forces produce an immediate and often startling redistribution of the precipitated granules, though they may not coalesce.

3. *Behavior of the precipitated droplets.*—In case of a petroleum film on the plate, the water droplets were sometimes seen to fall and float on the film, which is positive evidence against spurious droplets. They are usually black and circular in outline, but when the light is intense and axial, they are often colored. Fixed globules were apt to be larger and more irregular and pink or red in color. The color was eventually traced to the chromatic aberration of the objective used. This defect was rather useful in detecting clear globules, but it would be fatal in photography.

On tipping the microscope so that the light does not penetrate the vividly colored drops axially, they seem to cast shadows in opposed directions for symmetrical inclinations on both sides, as in fig. 2; but the phenomenon is probably a case of refraction† with the shadow beginning at the edge of a dis-

* It has thus far been difficult to produce an oily film free from flaw and quite glossy under the microscope, where surfaces are apt to be either reticulated or fluid.

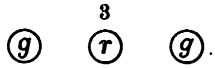
† That the effects described are associated with the aplanatic foci of spheres (as I at first supposed) is improbable. The globules lie on the oil film through which nearly parallel light enters. The caustic is not shown in fig. 2.

tinctly visible caustic. Similarly on moving the lamp horizontally to either side from the position corresponding to vivid pink color, fig. 3, and axial illumination, the globules become opaque and look like round shining steel beads. The diameter of the beads has but little effect on the axial or the other color.* If the lamp is moved until the field is dark, the plate looks like the starry heavens. These "stars" or foci are seen to be above the drops. They should lie (roughly) ·0003/·33 to ·0015/·33^{cm} above it.

2

After remaining in the plate for some minutes the fixed droplets often become rosette-shaped (apparently), at first (fig. 4) showing a mere black spot in the center of the color disc which gradually enlarges to a ring-shaped appearance *slowly moving radially outwards*. As a rule, the color is eventually the same on the inside and the outside of the enlarged ring, the ring itself appearing red with black demarcations in the surrounding green field as shown in the figure. On influx of air the structure becomes washed. The small globules when at first deposited never show the same color within and without, the former being uniformly red and the latter white. As the rings are not easily produced with a very viscous oil, it is

3



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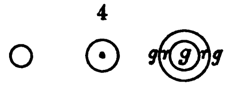


probable that the droplet has here penetrated to the glass and that the oil film is drawn over it by the capillary forces at the common edge of the three media. But the cause of the radial expansion is an interesting subject for conjecture.

4. *Preliminary measurements.*—Before adopting the eccentric focussing device, many experiments were made to ascertain the cause of the uncertainty in catching the drops on the plate when kept in place, seeing that sometimes the precipitation was abundant, while at other times, under the same apparent conditions, drops did not fall. Failures occurred both for high and for low nucleation. From the outset it was improbable that radiation from the outside could affect the result. It was eventually ascertained that on tipping the con-

* The degree of transparency will depend on the amount of contact of the globule and the oil film, and the floating globules are therefore sometimes quite opaque, at other times partially or wholly transparent.

densation chamber, after the fog had formed so that the subsidence would reach the plate obliquely, a precipitate would usually appear. Again, an oblique current within the chamber and passing across the plate usually produced a deposit. Hence, as the drops actually exist within the fog, success in bringing them down upon the plate is conditioned by very close isothermal adjustment of the plate to its surroundings, added to the advantages gained from incidental and favorable air currents. Thus a little time must always elapse before the drops persist at the plate, and therefore the droplets from a shallow capsule do not appear. Using a film of mica as a plate the result was the same, and it is useless to attempt to enumerate the drops by this method. Those which fall are carried in by grazing air currents, while no drops are obtained from the fiducial space under the objective. Cf. § 5.

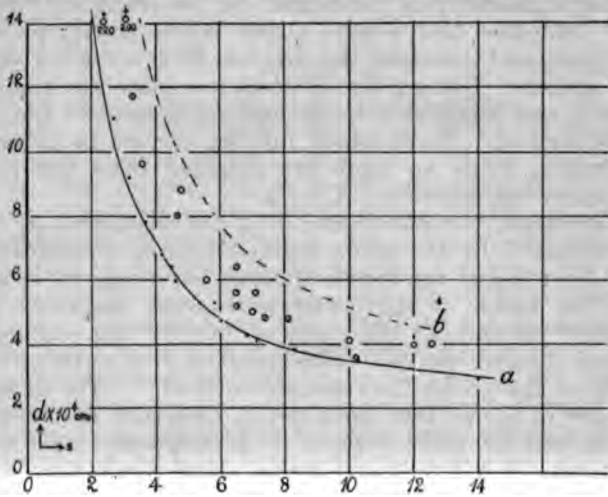
Nevertheless, the measurement of the diameters, *d*, of the drops obtained by the given method without modification is an excellent test of the results obtained elsewhere by computation. The factor of the ocular micrometer described above was $\cdot 002^{cm}$ per turn of the screw or $\cdot 00004^{cm}$ per scale part of the drum divided into 50. The extent of plate covered by the breadth of the spider lines was about $\cdot 0003^{cm}$. The finest particles are of about this diameter, so that such measurements must at best be much inferior to photography with a scale attachment. I will pass over the tabulated results here, merely stating that the coronal color with its diameter, *s* (chord of a radius of 30^{cm}), was observed when the eye and the source of light (Welsbach mantel seen through a small circular hole) were at distances 85^{cm} and 250^{cm}, respectively, from the center of the condensation chamber. The exhaustion was usually to a pressure difference of 17^{cm}, but this is of no significance when diameters are alone to be measured. The particles were collected by tipping the chamber, sometimes in large numbers, but at other times sparsely distributed without apparent cause. Nuclei were conveniently obtained from burning charcoal. Both floating and fixed globules were examined with strong microscopic illumination. It was difficult to retain a clear image without frequently removing the plate as the adjustment for focussing the plate within the chamber had not yet been adopted.

Floating globules were sometimes observed in the act of coalescing; but this is much rarer than the passage of a floating droplet* over a fixed one without interference. A distinct central red area, shading off into darkness, was seen even in the floating globules when axially illuminated by intense light. The larger drops were often metallically green. The colors

* Multitudes of fog particles are often seen moving in opposite directions across the field and turning about normally at the edges of a liquid film.

(chromatic aberration) vanish after long standing and they are particularly vivid immediately after falling. It was not even now possible, in spite of all precautions in tipping the vessel, to obtain an abundant crop of drops at pleasure.

If the results are given graphically in a chart in comparison with the computed data of my earlier experiments* as well as with my later† experiments, the observed results lie below the



latter where adiabatic conditions were assumed, and above the more recent experiments where the effect of the successive expansions was computed isothermally. In other words, the observed diameters were intermediate but nearer the older results.

5. *Number of droplets.*—The following results were obtained with the definite form of apparatus shown in figure 1. A method of estimating the nucleation from a direct count made under the microscope is obtained as follows: Let the plate s be rotated to s' so as to catch the descending fog particles for a definite interval of time, t. If v be their velocity of subsidence, all particles within a height, h, will be caught, if

$$h = vt \tag{1}$$

and

$$v = 10^6 d^2/3\cdot24 \tag{2}$$

where the usual value of the viscosity of air has been inserted. Furthermore, m grams are precipitated per cub. cm. by the given exhaustion, and if n be the nucleation

$$n = 6\,m/\pi d^3 \tag{3}$$

* Phil. Mag. (6), iv, p. 24, 1902. See curve b in the following chart.

† This Journal (4), xvi, p. 325, 1903. See curve a in the following chart.

Finally if c is the area of the field seen in the microscope and n' the number of particles falling into this field

$$n' = n\,h\,c \qquad (4)$$

From these equations n is obtained by eliminating v as

$$\sqrt[3]{n} = \frac{2\cdot 11 \times n'}{t\,c\,m^{2/3}\,10^{6}}$$

The values of the constants usually adopted were $t = 30$ sec., $c = 144 \times 10^{-6}$ sq. cm., $m^{2/3} = 2\cdot 8 \times 10^{-4}$, whence $\sqrt[3]{n} = 1\cdot 75 \times n'$.

The experiments to test this method often gave serviceable results some of which are inserted in the following tables; but at times the n-values are out of proportion The reason of this is three-fold: In the first place n is found from $n^{1/3}$ with the usual difficulty. Again, in a simple arrangement like the above, air currents cannot be quite excluded. They may arise incidentally in the apparatus, or the motion of the plate even,

TABLE I.—Observed diameters (d) of cloud particles and numbers (n) per cub. cm. $m = 4\cdot 7 \times 10^{-6}$ g per cub. cm.; micrometer factor ·00004cm. Distances of goniometer and light from condensation chamber, 85cm and 250cm; chord s for radius 30cm. Exhaustion to $\delta p = 17$cm.

	s	corona.	$c \times 10^6$	t	n'	n observed.	n computed.	d observed.	d computed.
	cm.		cm.²	sec.				cm.	cm.
	....	olive	140	30	37	270000	250000	....	....
	6·0	w r g	140	30	27	105000	90000	....	....
Phosphorus	10·2	w o b g′	70	30	17	210000	210000	·00036	·00036
nuclei....	7·4	w p b g	70	15	6	....	....	48	41
	7·1	w′ b p	....		..	....	....	56	42
	4·7	corona	....		..	....	....	80	61

Particles as small as ·0003cm present throughout.

	s	corona.	$c \times 10^6$	t	n'	n observed.	n computed.	d observed.	d computed.
Do.	6·5	g b p	140	15	10	43000	100000	·00064	·00046
	6·5	g′ b p	....					56	46

Particles graded as usual.

	s	corona.	$c \times 10^6$	t	n'	n observed.	n computed.	d observed.	d computed.
Air Nuclei .	4·5	corona	140	15	9	30000	40000	·00064	·00064
	6·5	g′ b p	....		..	....	....	52	46
	8·1	w c b g′	70	15	14	120000	150000	48	39
	8·2	Do.	70	15	16	180000	150000	....	39

Particles graded as usual.

if parallel to itself, may stir the air unless some form of guard ring attachment is added. Particles are thus swept down

upon the disc before and after the exposure, as was actually observed. The difficulty may be removed by adding a capsule above the plate or simply by decreasing the distance between the shield and the plate to a millimeter or less. Finally if the oil film is semi-fluid and not quite fixed, if there is slight creeping as was often the case, the particles are redistributed after falling along stream lines where they cohere in strings and bunches, usually without coalescing. This was also observed, and in fact the capillary forces involved are apt to be strong enough to counteract viscosity.

6. *Data.*—I have not thus far spent much time in correcting these defects, chiefly because the new results for the diameters of fog particles are more immediately interesting. Some data are given in Table I.

If the diameters measured are plotted in a chart, together with the results computed from successive exhaustions and coronal aperture s in the older (curve b) and in the more recent (curve a) experiments, the present values again lie between the two curves but now nearer the lower (recent) curve than before, § 4. I shall not pause to interpret the differences which remain, but only to remark that the capillary forces at the area of contact of the droplet, even with the liquid oil film, may transform it to an oblate spheroid and that diffraction at the circular edges of the drops is not excluded. Micrometric data cannot be smoother because the particles are not of a size for the same corona. If the nucleation n_0, obtained from successive isothermal exhaustions and subsidence measurement, be accepted as correct (lower curve a), the ratios of the nucleation found from the different methods tested will be

From subsidence, $a = {\cdot}0029$,	$d/d_0 = 1{\cdot}0$	$n/n_0 = 1{\cdot}0$
from lycopodium ($d = {\cdot}0032^{cm}$), $a = {\cdot}0034$,	" $= 1{\cdot}2$	$n/n_0 = {\cdot}61$
from diffraction (blue), $a = {\cdot}0034$,	" $= 1{\cdot}2$	$n/n_0 = {\cdot}61$
from micrometer measurement, $a = {\cdot}0037$,	" $= 1{\cdot}3$	$n/n_0 = {\cdot}48$
old results (adiabatic conditions assumed),	" $= 1{\cdot}6$	$n/n_0 = {\cdot}24$

Since n is obtained from the cube of d, large differences of this kind are as yet inevitable, particularly as the particles measured in these different cases are not the same.

7. *Graded nuclei.*—The point of special interest which comes out on using the eccentric plate to catch the subsidence during 15 or 30 seconds, and at once examining the deposit, is the result that particles of all sizes are present. By far the greater number, however, have the maximum diameter. These particles are caught from the fog without interference and it is not probable that coalescence or evaporation have been appreciably operative, so long as the corona remains the same throughout the micrometer measurement. The probable

explanation is this: while the pressure decrement is growing from zero to the maximum δp, condensation is taking place on the greater number of particles throughout the whole of this interval. In other words, although the nuclei are graded in size, the greater number exceed a certain dimension and require almost no pressure decrement to induce condensation. These are the particles (diameter exceeding a certain inferior limit) which give character to the *persistent* corona. A minority of the graded particles are below the dimension in question and upon these condensation does not take place until the higher values of the pressure difference are reached, some may even require the full pressure decrement, δp. Thus it is that in the deposit of fog particles, one finds those of diameter $\cdot 001^{cm}$ intermixed with others of smaller diameter, even as far as $\cdot 0002^{cm}$ or less. When fresh phosphorus nuclei are first introduced into the condensation chamber the result is a grey fog, but a relatively small white reddish corona is nevertheless discernable. Accordingly the crop of droplets seen under the microscope contains not only surprisingly small but also relatively large droplets, with all intermediate diameters. Hence the indefinite fog and the small corona. The large olive (g b p) corona and other of the early coronas are very apt to *fade* into a coarse white reddish corona. This is the evaporation of the smaller particles into the larger, which accounts moreover, for the loss of nuclei during the first precipitation, to be caught in subsequent exhaustions. The successive coronas in a series gradually become sharper and the larger particles more uniform, but extremely fine particles are still present even when one approaches the normal coronas. The fine particles, however, belong to coronas so large and diffuse that their coronal effect scarcely modifies the strong coronas of the large particles, even before the former vanish by evaporation.

When I first observed these different sizes of drops caught on a single plate, it seemed not improbable that a difference of the condensational effect of the negative and the positive ions might here be actually in evidence; but as all intermediate sizes are present at the outset, and particularly as large and small droplets still appear together long after all electrification has certainly vanished, this conclusion is not warranted. What continually favors uniformity is subsidence of fog. As the phosphorus nuclei are graded, it is probable that the very fine droplets are due to the initial or primitive nuclei from which the larger nuclei have grown by cohesion; or the fine droplets may be due to air nuclei associated with the phosphorus nuclei. All this will appear in a more minute photographic study of the subject with which I am now engaged, and it will then be further interesting to decide whether the nuclei generated

by the X-rays are not also graded below a certain usually much smaller maximum diameter, and, in general, to ascertain where the nuclei originate. That this maximum diameter will increase with the lapse of time allowed for coherence may be inferred from my experiments with the steam jet: X-ray nuclei will not act upon the steam tube unless a certain time is allowed for growth, as I understand it. The coarse and washed type of coronas obtained with nuclei produced by the X-rays is evidence of graded size, while the fog particles, so far as I have yet caught them, are of varied dimensions. In these cases the X-rays reached the inside of the condensation chamber through its waxed wood walls lined with wet cloth. To obtain a fairly strong and large corona an exposure to the rays lasting 5 to 10 minutes was needed, as the radiation was not very intense. In this interval the original extremely small nuclei are probably undergoing continuous growth, for instance by cohering, so that on exhaustion particles of all sizes* are revealed. In addition to the ragged coronas there is copious rain.

* Under these circumstances it seems reasonable that the time loss of nuclei must at the outset be proportional to the square but finally to the first power of the number, assuming that eventually the large nuclei do most of the catching.

Brown University, Providence, R. I.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *Formation of Ozone.*—When an electric discharge was assed in a tube of fused quartz evacuated to a few millimeters f mercuric pressure, it was noticed by E. Goldstein that an ntense odor of ozone was produced in the vicinity of the quartz ube. Potassium iodide and starch paper were quickly made blue y the product. The odor disappeared instantly when the dis- harge was interrupted. The phenomenon appeared when the as pressure in the tube was varied rather widely; it was most ntense when the light from the tube was brightest. Narrow ubes were found to be preferable to wide ones for the purpose. No odor of ozone was perceptible when glass tubes were used in lace of those of quartz. The author believes that the phenom- non is due to the action of ultra-violet rays of very small wave- ength, which pass through the quartz glass and convert the xygen of the air into ozone.

When a U-shaped quartz tube, through which the discharge vas passing, was dipped into liquid air, noticeable ozonization lid not appear to take place. It is possible that the ozone in the ir surrounding a quartz discharge-tube might have been con- lensed by cooling, but it seemed preferable to make the experi- nent with oxygen inside of a tube where the production of ozone vould probably be greater. Experiments showed that it was ossible to convert oxygen entirely into ozone within a Geissler's ube, which, in this case, was made entirely of glass, by cooling portion of the tube with liquid air and admitting oxygen rom time to time in proper quantities. The cooled part of the ube quickly became coated with a blue layer of liquid ozone. When the tube was removed from the liquid air the blue liquid an down the walls of the tube and collected at the bottom as a lackish-blue liquid. When a part of the tube was kept cool with iquid air the pressure within the tube fell to about $\frac{1}{10}^{\text{mm}}$ and this ressure remained constant as long as liquid ozone was present, ven when the tube was pumped out as far as possible. This ndicated that all of the oxygen was converted into ozone and it howed the tension of ozone at the temperature of liquid air. No spontaneous explosions of the liquid ozone took place during hese experiments, such as were observed by Ladenburg when zone was condensed under atmospheric pressure.—*Berichte*, xxvi, 3042. H. L. W.

2. *A Peculiar Property of Some Hydrated Salts.* — A. de Schulten observes that, as a general rule, where salts form everal hydrates, the hydrate richest in water gives the lower ydrates by successive increases in temperature. For instance, $MgSO_4 \cdot 12H_2O$, at a few degrees above freezing is changed to $MgSO_4 \cdot 7H_2O$, while at 52° $MgSO_4 \cdot 6H_2O$ is formed, and at 132°

$MgSO_4 \cdot H_2O$ is produced. Many other cases of this usual manner of transformation are known. The peculiarity to which attention is called is the behavior of certain hydrates which do not act in the usual way in this respect. Three examples are given. Gay-lussite, $CaCO_3 \cdot Na_2CO_3 \cdot 5H_2O$ loses the whole of its water at 100°, while pirssonite, $CaCO_3 \cdot Na_2CO_3 \cdot 2H_2O$, does not undergo any change at 100°, and it is only at a temperature of 130° that it loses the whole of its water. The compound $Mg_3(PO_4)_2 \cdot 22H_2O$, at 100°, quickly loses 18 molecules of water, and then very slowly loses more water, while artificial bobierrite, $Mg_3(PO_4)_2 \cdot 8H_2O$, does not undergo any alteration at 100°. The arseniate $Mg_3(AsO_4)_2 \cdot 22H_2O$, corresponding to the above phosphate loses 17 molecules of water very quickly at 100°, while artificial hoernesite, $Mg_3(AsO_4)_2 \cdot 8H_2O$, does not change at all at 100°.—*Bulletin*, xxix, 724. H. L. W.

3. *Attempts to Prepare Nitrogen Fluoride.*—Several years ago it was announced by Warren that he had prepared a fluoride of nitrogen in oily drops by the electrolysis of ammonium fluoride solution. Moissan failed to produce any such compound by the action of fluorine either on nitrogen or ammonia. RUFF and GEISEL have recently attempted to prepare the compound by Warren's method, and by other methods which suggested themselves, and after an elaborate series of experiments were unable to obtain any evidence of its existence. It seems probable that Warren used ammonium chloride, and that the explosive body obtained by him was merely nitrogen chloride.—*Berichte*, xxxvi, 2677. H. L. W.

4. *Quantitative Chemical Analysis*; by the late DR. C. REMIGIUS FRESENIUS. Authorized Translation of the Sixth German Edition by ALFRED I. COHN. 2 vols., 8vo, pp. 780 and 1255. New York, 1904 (John Wiley & Sons).—This voluminous work is apparently an absolutely complete translation of the last German edition, which appeared in 1875, twenty-nine years ago. The translator has made a number of additions. In the first part, which is the systematic treatment of the subject, the additions are practically confined to those introduced by Johnson and by Allen, and to be found in the last American edition of 1881. It is to be noticed, however, that modern atomic and molecular weights have been substituted for older ones throughout the work. The second or special part of the book contains occasional additions by the translator of modern methods, and as appendices are added the methods of analysis adopted by the Association of Official Agricultural Chemists, and also Hillebrand's treatise on Rock Analysis.

It is to be regretted that the translator abandoned his original intention of inserting many of the more recent and improved methods of chemical analysis, for space might have been gained for these by the omission of the antiquated methods thus supplanted; but the reverential attitude of the translator was evidently such that it seemed improper to omit anything. However,

should be observed that a large part of the inorganic analysis f thirty years ago is applicable at the present time, and that iis classical work of Fresenius must still be considered the standrd reference book on the subject. H. L. W.

5. *The Analytical Chemistry of Uranium;* by HARRY BREAREY. 8vo, pp. 45. London, 1903 (Longmans, Green & Co.).—'his little book deals chiefly with the author's experience in etermining uranium, in separating it from the associated eleients, and in descriptions of analyses of uranium minerals. In iew of the present importance of uranium ores as sources of adium, it seems remarkable that this interesting metal is not ientioned in the book under consideration in the list of elements ccurring in pitchblende. It is still more remarkable that the uthor apparently is not familiar with the discovery of helium, or he mentions nitrogen as a constituent of pitchblende and efers only to Hillebrand's work on this subject. H. L. W.

6. *Chemical Calculations;* by H. L. WELLS. 8vo, pp. 58. Iew York, 1903 (Henry Holt & Co.).—The first thing noticed on pening this book is the excellent arrangement of the logarithm ables, which are provided with a thumb-index and are exceedigly convenient for such calculations as a chemist usually has to iake. There is a table of gravimetric factors for calculating nalytical results which is very complete, and a convenient set of ables to be used for gases. Also, a table for calculating indirect nalyses, and another to be used in calculating fluxes to form lags. The second part of the book explains briefly, with examples, ow the tables are used. H. W. F.

7. *Solar Radiation and the Pressure of Light.*—This subject s discussed in an important paper by Professor POYNTING of the Jniversity of Birmingham. The author takes the fourth power aw, $R = \delta\theta^4$, where R is the energy radiated per sec. per cm. by full radiator at temperature θ°A (A stands for the absolute cale) and δ is the constant of radiation. According to Kurlaum

$$\sigma = 5{\cdot}32 \times 10^{-5} \text{ erg.}$$

Taking the various values given by different observers of the olar constant, Poynting calculates the effective temperature of he sun, and places it between 6000° A and 7000 A—more exactly t 6200° A. The effective temperature of space is then 10° A. f a body, therefore, is raised to a small multiple of 10°—say 60° —the fourth power law of radiation implies that it is giving out nd, therefore, receiving from the sun more than a thousand imes as much energy as it is receiving from the sky. The sky adiation can, therefore, be left out of account, when we are lealing with approximate results, and bodies in the solar system nay be regarded as being situated in a zero enclosure except so ar as they are receiving radiation from the sun.

On the supposition that the moon does not conduct inward, its ipper limiting temperature is found to be 371° A, just below the emperature of boiling water. Langley estimated the tempera-

ture of the moon to be a few degrees above the freezing point. On the supposition that three-fifths of the heat is conducted inward, Poynting calculates the upper limit at 297° A. He also calculates the temperature of fully absorbing spherical bodies of 1^{cm} in diameter at the distance of the earth from the sun and finds the temperature $\theta = 300°$ A. This will be the temperature of bodies smaller than 1^{cm}, so long as they are not too small to absorb all the radiation falling upon them. The variation of temperature with distance from the sun is next estimated; the author regards it as highly probable that the temperature of mass is everywhere below the temperature of freezing point of water. The only escape from this conclusion is to suppose an appreciable amount of heat issuing from his surface. Considering a comet as made up of small particles of the order 1^{cm} or less, these particles twenty-three million miles from the sun would have the temperature of melting lead, and at three and three-quarters million miles, the temperature of cast iron (1500°).

Poynting then discusses the value of the radiation pressure. Bartoli showed that a pressure must exist without any theory in regard to the nature of light, beyond a supposition that a surface can move through the ether, doing work on the radiation alone, and not on the ether in which the radiation exists. The most interesting part of the paper is that which deals with a comparison between mutual gravitation and radiation pressure of small bodies. Poynting calls attention to the fact, that if the radiating body is diminished in size the radiation pressure due to it also decreases less rapidly than the gravitative pull which it exerts. The radiation decreases as the square of the radius of the emitting body and its gravitational pull as the cube. It is also noted that equality of action and reaction does not hold between the radiating and receiving bodies alone. The ether is material and takes its part in the momentum relations of the system. Two globes of water, probably nearly full absorbers at 300° A, will at that temperature neither attract nor repel each other if their radii are about 20^{cm}. Small particles of the order 1^{cm} radius would be drawn into the sun even from the distance of the earth in times not large compared with geological times. Near the sun the effects are vastly greater. The application to meteoric dust in the system is obvious. The entire paper pleads for an extension of our idea of matter to include the medium. Bodies do not act upon each other; each sends out a stream of momentum into the medium surrounding it. Some of this momentum is ultimately intercepted by the other, and in its passage the momentum belongs neither to one body nor to the other. The action on one of the bodies is equal and opposite to the reaction on the light-bearing medium contiguous to it.—*Phil. Trans. of Roy. Soc.*, Series A, vol. ccii, pp. 525–552. J. T.

8. *Blondlot's n-rays.*—BLONDLOT describes a new species of rays which he terms *n*-rays. These rays are given out by the Auer-burner or still better by the Nernst lamp. They penetrate alumi-

a : are absorbed by the smallest layer of water : acting like g heat waves. While they are absorbed by cold platinum y easily penetrate red-hot platinum. These *n*-rays radiate m the Nernst lamp long after this lamp is extinguished, and ca exposed to the sun's rays show these rays.

)r. O. LUMMER calls attention to the physiological effects on retina produced by experiments similar to those of Blondlot, suggests that the *n*-rays are merely ghostly images produced the structure of the retina and its nerves by the method of ervation pursued by Blondlot. The phenomena observed by latter appear to be the result of the struggle between the s and cones of the retina in the effort to fix our vision in the k.—*Deutsch. Physikalisch. Gesellsch.*, v Jahrg., Nr. 23. J. T.

. *The Rowland Effect.*—The magnetic effect of electric convec-ı has been tested by Wilson, Adams and Pender and Eichen-d. In addition to these investigators is now HIMSTEDT, who olishes a quantitative investigation in the hope of adding nulative evidence. One series of trials gave for the value of he ratio of the electrostatic to the electromagnetic units, 3·04; l a second series, 2·99. Himstedt's experiments, therefore, firm Rowland's results.—*Ann. der Physik*, No. 1, 1904, pp. –123. J. T.

II. GEOLOGY AND NATURAL HISTORY.

. *United States Geological Survey.*—The following publica-ns of the U. S. Geological Survey have recently been received:

MONOGRAPH XLV. The Vermilion Iron-Bearing District of nnesota, by J. MORGAN CLEMENTS. 447 pp., 13 pls., 23 figs., atlas sheets. This is the fifth of the monographs published the Survey which deal with the geology of the various iron-ducing districts of the Lake Superior region. The ore deposits, ich make the region of great interest, are strikingly like those the Marquette district. The ore bodies are usually found ner at the bottom of a highly folded chert or jasper formation l resting upon an underlying igneous mass folded into a syn-ıal trough, or within the iron-bearing formation and resting on intercalated silts or intruded dikes of igneous rock. The de of origin assigned to the ore bodies is the same in general that given for the other districts, and which has been described detail by Van Hise in the monograph on the Penokee district. The monograph is well illustrated and is accompanied by an as giving detailed maps of the area. A useful feature is the roductory outline, which gives a brief summary of the matter ated in the book. W. E. F.

BULLETIN No. 211. Stratigraphy and Paleontology of the per Carboniferous Rocks of the Kansas Section, by GEORGE I. AMS, GEORGE H. GIRTY and DAVID WHITE. 123 pp., 1903. e area covered is situated in Eastern Kansas, and represents

exposures of a continuous series of beds; sandstones and shales and interbedded limestones, of 3250 feet thickness. An erosional unconformity limits them below, somewhere in the lower part of the Upper Carboniferous, and the uppermost formations are regarded as Permian.

Forty-seven distinct formations are recognized, giving an average of about seventy feet to a formation. No attempt is made by the author to form more comprehensive divisions of the whole, as was done by Haworth and by Prosser, since the sedimentation is found to be continuous, oscillating between sets of dominantly calcareous beds and sets of beds dominantly shaly, the fossils occurring more richly in the limestone or calcareous formation. "*The evolution of the latest from the earliest faunas,*" is said, by Girty, to be "*without marked interruption at any point so that subdivisions appropriate for recognition are not clearly apparent.*" No classification of the beds seems to be especially favored by the evidence of invertebrate paleontology.

David White reports on the Plants from the Kansas beds and finds the majority of them typical Coal Measure (Pennsylvanian) species, while those from the Marion and Wellington formations at the top of the section, identified by Sellards, indicate Permian age. H. S. W.

FOLIO NO. 94. Brownsville-Connellsville folio, Pennsylvania, by MARIUS R. CAMPBELL. This geological map and its explanation is an admirable example of the thorough work produced by the Survey. The region covered is in southwestern Pennsylvania, in the midst of rich coal and gas fields. The survey is based upon triangulation surveys, and topography of the surface as well as the underground structure are elaborated in detail. Numerous stratigraphic sections of mines (92 are figured and described) are given and the productive horizons of numerous gas wells determined. The classification of the formations is the usual one, with the thickness for this region as follows, viz:

? Permian	Dunkard	300′
Pennsylvanian	Monongahela	310–400′
	Conemaugh	600′
	Allegheny	280′
	Pottsville sandstone	150′
Mississippian	Mauch Chunk	150′
	Pocono	400′

The Pocono sandstone is at its top developed into a siliceous limestone. In the midst of the Mauch Chunk, the Greenbriar limestone is developed as a lentil from 0 to 30 feet thick, fossiliferous; it is shown to be of Chester age. An unconformity is recognized at the base of the Pottsville, the lower member of which is believed to represent the Conoquenessing sandstone. In the Conemaugh formation a crinoidal limestone (the Ames limestone), four feet thick, is seen below the Morgantown sandstone.

The upper Coal Measures (Monongahela) contains the important Pittsburg, Redstone, Sewickly, Uniontown and Waynesburg coals. Between the Sewickley and Uniontown the so-called "great limestone" occurs to which the name Benwood limestone is applied. Many productive gas wells are scattered over the Brownsville quadrangle, statistics of which are given. H. S. W.

2. *On the Geology of the Hawaiian Islands;* by WM. H. DALL. (Communicated.)—In the article by Dr. Branner on the Geology of the Hawaiian Islands, in the October number of the Journal, he comes (pp. 306–309) to a different conclusion with regard to the calcareous layers interstratified with the tuffs of Diamond Head, Oahu, from that to which I was led in 1899. This difference is probably due to the fact that Dr. Branner did not see all the area which I examined and reasoned from certain beds which he did see and which are doubtless of a different nature from those to which I referred.

I found oysters, *Chama*, and numerous corals, fossilized as they grew, and still adhering to the nearly horizontal surface of the continuous thin sheet of lava which formed the basis of an area of very considerable extent entirely outside of the slope of the tuff cone but apparently continuous under it. The particular horizon which I examined formed the top of the ground for a considerable distance inland, and the circumstances are entirely incompatible with the idea of a subaërial formation. That there may be subaërial formations around Diamond Head in some places is highly probable, but that is another story.

Smithsonian Institution, Washington, D. C., Dec. 15, 1903.

3. *Geological Commission, Cape of Good Hope;* G. S. CONSTORPHINE, Director. Annual Reports, 1900, 1901, 1902.—The geological work for 1900 was mainly in the district west of the Karroo plateau. A new formation (the "Ibiquas Series") is reported lying between the Malmesbury beds and the Table Mountain sandstone. Glaciated pebbles were found in the Table Mountain series (early Devonian). The underlying unconformity of the Dwyka conglomerate (this Journal, xiii, 413) is changed to conformity at the south. Dolerite sheets and dikes cut the Paleozoic sediments. Announcement is made of the discovery of a new Mesozoic swimming reptile.

Owing to the Transvaal war, the geologists of the Commission spent the season of 1901 along the southeast coast line making a general survey of Transkei and Pondoland with special studies of the Cretaceous of Pondoland and of the igneous rocks (granite, diorite, dolerite) of Kentani. The map shows a remarkable adjustment of streams to the diorite. During 1902 Mr. E. H. L. Schwartz made a survey of parts of the Matatiele Division in Griqualand East. Perhaps the most interesting part of his work is the description of a row of 19 volcanic necks trending northeasterly, from which issued the lavas which form the crest of the Drakensbergs. The cones and flows are deeply eroded or destroyed on their east (wet) side but are well preserved on their west side.

"The sedimentary rocks through which the chimney is pierced never show the least shattering or plication." A petrological examination of these volcanics (pp. 65–96) shows them to be dolerites and basalts. The common type is the "amygdaloidal melaphyre" with long, narrow branching vesicles as first described by Cohen (Neues Jahrbuch, 1875). Mr. A. W. ROGERS was appointed acting geologist in 1902, and, in addition to his official duties, surveyed parts of Beaufort West, Prince Albert and Sutherland Divisions. A classification of strata has been adopted for Cape Colony which in outline is as follows:

Superficial Deposits.	Dunes; Alluvium, Laterite, Esturine and River Deposits.
	Pondoland Cretaceous Series
	Uitenhage Series
Karroo System (Permian Jurassic ?)	Stormberg Series Beaufort Series Ecca Series Dwyka Series
Cape System (Devonian ?)	Witteberg Series Bokkeveld Series Table Mountain Series
Pre-Cape Rocks In the south and west of Cape Colony	Ibiquas Series Congo Series Malmesbury Series
Pre-Cape Rocks In north and northwest of Cape Colony	Matsap Series Griqua Series Campbell Rand Series 'Kreis Series Namaqualand Schists ?

The vertebrate fossils from these series are now being examined by Professor Seely; the plants by Mr. Seward; the invertebrates by Mr. Lake, Mr. Kitchen and Mr. Chapman. Until these fossils are reported on, correlation will not be attempted.

It is to be regretted that suitable maps and sections do not accompany these reports.

4. *Geological Society of South Africa* (Transactions, vol. vi, parts 1, 2, 4).—The most recent publications of the Geological Society of South Africa contain papers by E. P. RATHBONE on the Geology of the DeKaap Goldfields; by J. P. JOHNSON on sections at Shark River and the Creek, Algoa Bay; by G. S. CORSTORPHINE on the age of the Central South African Coalfield; by G. A. F. MOLENGRAAFF on the Vredefort Mountain Land. The Vredefort region consists of a granite intrusion with zones of metamorphosed sediments. In part 4 are papers by J. P. JOHNSON, on the Discovery of Implement-bearing beds near Johannesburg in which Eolithic, Palaeolithic and Neolithic forms are described; by A. R. SAWYER on the Origin of the Slates on the Rand and on the Vredefort Granite Mass; by F. H. HATCH on the Black Reef Series; by J. KUNTZ on Pseudomorphosis of Quartz Pebbles into Calcite.

5. *The Action of Radium, Roentgen Rays and Ultra-Violet Light upon Minerals and Gems.*—An article by G. F. KUNZ and C. F. BASKERVILLE upon this subject is given in full in the issue of Science for Dec. 18, 1903. A number of minerals, including diamond, willemite, kunzite, pectolite, topaz, fluorite, autunite, etc., were subjected to these different forms of radiation and a considerable part found to respond. Of these, willemite, the violet-colored spodumene called kunzite and diamond were the most responsive to all forms of activity; the possibility of the presence of some undetermined element with the willemite (also hydrozincite, etc.) is suggested. In the case of minerals from Borax Lake, California, of different composition but which all phosphoresced with ultra-violet light, though not with radium, the existence of an element explaining this property is also suggested. The whole subject is one calling for much additional investigation.

6. *Optical Characters of Anthophyllite: a Correction;* by C. H. WARREN. (Communicated.)—The writer wishes to make a correction regarding the optical orientation of the anthophyllite from Rockport, Mass., described in this Journal, vol. xvi, November, 1903, p. 341. The orientation should be: $c' = \mathfrak{c}$, $a = \mathfrak{a}$, $b = \mathfrak{b}$, thus making the mineral optically negative.

The error was due to the fact that a quartz wedge was used in making the determinations, which was cut with the vibration direction of fastest ray opposite to that of this ray in the wedges to which the author had always been accustomed. Until very recently no occasion had arisen to use this particular wedge for the determination of a known mineral and so the error remained unnoticed.

7. *Chemical Composition of Igneous Rocks expressed by means of Diagrams;* by J. P. IDDINGS. U. S. Geol. Surv. Professional Paper, No. 18, Washington, 1903, 4°, 92 pp., VIII pl.—The author of this paper was one of the first petrographers to express the chemical relationships of igneous magmas, revealed in their chemical analyses, by graphic means. In recent years we have seen this instrument used by different petrographers in a variety of ways to develop special features, but never before has it been employed with so great a breadth of scope and on a plan so comprehensive as in the present work. The idea is to express pictorially to the eye the mutual chemical relations of all analyzed igneous rocks. For this purpose a double diagram method is used. Each analysis has its molecular ratios calculated and these are referred to a system of axes, and the points on the axes connected with each other by lines. The triangles thus formed are tinted with different colors and this enables the eye at a glance to perceive the relations of the molecular oxides and their capacity for forming feldspathic and ferromagnesian molecules. These are the individual diagrams. The small individual diagrams so formed are then placed in a very large diagram in which their centers or zero points are referred to a set of rec-

tangular axes in which the abscissas are the percentages of silica and the ordinates are the ratios obtained by dividing the molecular proportions of the combined alkalies by the molecular proportions of the silica. This point forms the locus of the small diagram.

In the first table are given the small colored diagrams of over 950 analyses of igneous rocks having over 28 per cent of silica, selected to show all possible variations. The table is continued and completed in plate viii, which shows the rocks with less than 28 per cent of silica. In another table are shown the loci of the alkali-silica ratios of over 2000 analyses; in this case the individual diagrams are omitted and the loci shown by simple dots. In other plates are shown the diagrams of analyses, disposed as in plates i and viii, divided and arranged according to the new quantitative chemical classification recently proposed by Cross, Iddings, Pirsson and Washington.

There are many interesting and instructive features shown by these diagrams which must be seen to be appreciated. Perhaps the most convincing thing they prove is the impossibility of any "natural" classification of igneous rocks and that any division lines must of necessity be wholly arbitrary ones.

The work is certainly a tribute to the patience and industry of the author, a reflection that is forced home when one thinks of the vast number of analyses that have been computed and carefully arranged in these diagrams. Whatever evidence they present certainly does not lack weight for want of facts to sustain it. L. V. P.

8. *Petrographisches Prakticum;* von R. RHEINISCH. Part II, Gesteine. Pp. 180, 8°. Berlin, 1904 (Gebr. Borntraeger).—The first part of this work has been previously noticed in this Journal (vol. xiii, p. 243, 1902). The object of this elementary treatise is to afford help to the beginner in the study of rocks; it is not intended as a complete text-book and its use demands some previous acquaintance with the elements of the science. The igneous rocks, the sedimentary rocks and the crystalline schists are briefly treated. The "dike rocks" are not assigned a separate position but are mentioned under the abyssal granular types. The system of classification followed is essentially that of Zirkel. Each rock is briefly described, its mineral composition mentioned, a few mass analyses given and the more important localities, especially the German ones, stated. The book is well gotten up and appears carefully written and will no doubt prove useful in Germanic countries. The thought that strikes one in connection with it is, that since a knowledge of the subject and the use of the microscope are implied, why not use one of the larger textbooks at once in which all phases of the subject are covered and more information given. L. V. P.

9. *Les Roches alcalines caracterisant la Province pétrographique d'Ampasindava;* par A. LACROIX. Nouv. Archiv. du Muséum, 4 ser., v, 4°, pp. 171–254, pl. 14, 1903.—It will be

recalled that some time since Professor Lacroix published an important memoir upon an interesting series of alkaline rocks from the northwest coast of Madagascar as noticed in this Journal, vol. xiv, page 396, 1902. In the present work a new series of similar rocks from other localities in the same province is described with analyses by PISANI, syenites, foyaites, tinguaites, monzonites, etc., which thus extend the limits of this petrographic province in a most interesting way. L. V. P.

10. *Notes on the Rocks of Nugsuaks Peninsula and its Environs, Greenland;* by W. C. PHALEN. Smithson. Misc. Coll. Quart. Issue, vol. xlv, pp. 183–212, 1904.—A petrographic description accompanied by analyses of rocks collected in 1897 by Messrs. Schuchert and White. The rocks are mostly granular crystallines, granite, syenite, diorite, etc., and there is a complete description of the iron-bearing basalt. The work is carefully done and adds to our knowledge of the petrography of the northern lands.
L. V. P.

11. *Monograph of the Coccidæ of the British Isles;* by ROBERT NEWSTEAD. Volume I, 1901; pp. xii+220; text figures 20; 39 plates. Volume II, 1903; pp. 270; text figures 7; 42 plates. London (printed from the Ray Society).—The second and final volume of Mr. Newstead's careful and very praiseworthy monograph of the British scale insects has just been published. The entomological monographs published by the Ray Society have not always been of the first rank, but this one of Mr. Newstead's deserves very great praise. Many of these Ray Society monographs have been devoted to the consideration of the fauna of the British Isles, and from its title this would seem to be of equally limited scope. As a matter of fact, the author has only included species which have actually been found living in Great Britain and Ireland, but with the Coccidæ the conditions are such that a far more general interest attaches to this monograph than any of the others which have been geographically so limited. Perhaps the majority of the Coccidæ of the world have, through the constant interchange of plants, become practically cosmopolitan. It is difficult with the majority of species at this late date to decide the probable original home. The result is that by far the larger number of species treated by Mr. Newstead have been introduced into Great Britain, and have established themselves there. To illustrate the interest which American investigators will have in this monograph, of the thirty-six species of Diaspinæ treated in volume i, thirty occur also in the United States, and, of the remaining six, three have been found only in greenhouses in Great Britain and are probably species introduced from some other part of the world. Compared with the world fauna in the Coccidæ, however, the number of species treated in the monograph is, of course, small, and hence some of the generalizations made by the author as to generic distinctions and those of higher groups will possibly be open to criticism when larger series are studied. It seems to the writer, for example,

that an error has been made in confusing the species of the true genera Diaspis and Aulacaspis, since the arrangement of the dorsal tubular spinnerets in the female has been used as the striking character with these and some allied genera, rather than the more important structural characteristics of the anal plates. Some day I fear there will be a general untwisting of Mr. Newstead's assignment of the species of this genera.

An important contribution to the literature of the much-discussed male of *Lecanium hesperidum* occurs in volume ii, and Mr. Newstead describes the second stage and the puparium of what is undoubtedly the true male of this species. He indicates that the male, as was quite to be expected, belongs to the true Lecanium type, and that the alleged discovery by Moniez had probably reference to one of the Chalcidid parasites which universally infest females of this species.

The many illustrations, and especially those upon the plates, all done by Mr. Newstead himself, are better done than any figures of Coccidæ which have heretofore been published.

The revised nomenclature of the Coccidæ, as displayed by Mrs. Fernald in her Catalogue of the Coccidæ of the World, and which must probably be accepted, is not followed in the text proper, but in an appendix to volume ii it receives proper recognition.

L. O. HOWARD.

12. *Catalogue of the Lepidoptera Phalænæ in the British Museum*, Vol. IV. Catalogue of the Noctuidæ; by SIR GEORGE F. HAMPSON. Pp. xx, 689, with an accompanying part containing plates lv–lxxvii. London, 1903.—The issue of Part IV of the British Museum Catalogue of Moths will be welcomed by all interested in this subject. It contains descriptions of some 1200 species of the Agrotinæ, the first of the fifteen sub-families of the Noctuidæ. The plates, reproduced by trichromatic photography, are very beautiful and show the perfection to which the process has been brought.

13. *General Zoology;* by C. W. DODGE. 482 pp., 379 figs. (American Book Company.)—Professor Dodge has revised and re-arranged "Orton's Comparative Zoology" in a way which is highly satisfactory to the teacher and to the general student.

III. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *American Association.* — The fifty-third meeting of the American Association for the Advancement of Science was held at St. Louis during the week from December 26, 1903, to January 1, 1904. Dr. Carroll D. Wright was President of the meeting. The address of the retiring president, Dr. Ira Remsen, was delivered on December 28th, on the subject "Scientific Investigation and Progress." This address is given in the issue of Science for January 1 and the following numbers of the same periodical give a full account of the proceedings. Affiliated societies to the number of twenty-one held meetings in conjunction with the

Association. The total attendance, including 81 in the societies, was 466. The new policy of holding winter meetings, with its obvious advantages and disadvantages, was upheld and the next meeting appointed for Philadelphia, beginning Tuesday, Dec. 27, 1904. New Orleans was recommended for the meeting two years hence. The following officers were elected for the Philadelphia meeting:

President: W. G. Farlow, Cambridge, Mass. *Vice-Presidents:* Section A, Alexander Ziwet, Ann Arbor, Mich.; Section B, W. F. Magie, Princeton, N. J.; Section C, L. P. Kinnicutt, Worcester, Mass.; Section D, D. S. Jacobus, Hoboken, N. J.; Section E, E. A. Smith, University of Alabama; Section F, C. Hart Merriam, Washington, D. C.; Section G, B. L. Robinson, Cambridge, Mass.; Section H, Walter Hough, Washington, D. C.: Section I, M. A. Knapp, Washington, D. C.; Section K, H. P. Bowditch of Boston. *General Secretary,* Charles S. Howe, Cleveland, Ohio. *Secretary of the Council,* C. A. Waldo, Lafayette, Indiana.

2. *Carnegie Institution of Washington, Year Book, No. 2, 1903.* Pp. lix, 311. Washington, January, 1904 (published by the Institution).—This second volume from the trustees of the Carnegie Institution will be widely welcomed since all the facts in regard to the administration of this fund cannot but be of great interest to every one concerned with the progress of scientific research of the country. It is a matter of general congratulation that this unique work has been initiated and thus far carried on with so much liberality and wisdom. The opening part of the volume (pp. i–lix) contains administrative matters including the minutes of the Board of Trustees, the Report of the Executive Committee on the work of the year and memorials of Abram S. Hewitt, William E. Dodge and Marcus Baker. Following this are a series of seven papers including reports on southern and solar observatories, reports relating to geophysics, original memoirs in several departments.

The list given of the grants, aggregating nearly sixty, made during the year out of the sum of $200,000 set apart by the Trustees at its last annual meeting, shows the wide range of scientific inquiry aided by the Carnegie Institution; with each statement a brief account of the results thus far obtained is included. It is interesting to note that the demand upon the funds of the Institution is much greater than it can meet; thus it is stated that from the beginning until Oct. 31, 1903, the total number of requests for aid was 1,042 and these called for an expenditure of $2,200,398. To this sum are to be added the grants recommended by the Advisory Committee aggregating $911,500, thus giving a total possible expenditure of $3,111,898. Although but a small part of the demands for assistance in research can be favorably acted upon, the total amount of good that may be expected from the money actually paid out is very large indeed.

3. *Physikalisch-chemisches Centralblatt.*—The first number of the Physico-chemical Review, announced on p. 475 of the last

volume, has recently been issued under date of December 15, 1903. It contains thirty-two pages and gives seventy-nine abstracts, of physical and chemical papers, in German, French or English, according to their original source. It is much to be hoped that this new review may meet with the general coöperation and support which it deserves.

4. *A Description of the Brains and Spinal Cords of Two Brothers dead of Hereditary Ataxia;* by LEWELLYS F. BARKER. The Decennial Publications of the University of Chicago, First Series, Vol. X, 38 pp., 4to, with twelve plates. Chicago, 1903. (The University of Chicago Press.)—This memoir gives the results of an examination, in part microscopic, of the brains and spinal cords of two brothers, who died of hereditary ataxia. These were cases XVIII and XX of the Series in the family described by Dr. Sanger Brown, who gives here a clinical introduction. Twelve plates with forty-six figures follow the text.

5. *Field Columbian Museum.* — Publications 79, 80 of the Zoological Series, Vol. III, Nos. 12, 13, have recently been issued. The former, pp. 199–232, contains a list of mammals collected by Edmund Heller in Lower California, with descriptions of apparently new species. The latter, pp. 233–237, gives descriptions of apparently new species of *Heteromys* and *Ursus* from Washington and Mexico. Both papers are by D. G. Elliot.

6. *The Planetary System;* by F. B. TAYLOR. 268 pp. Published by the author, Fort Wayne, Indiana.—If Newton's solution of the problem of three bodies were correct it ought to yield a general law for the stability of inner satellites. His analysis, however, shows only indeterminate stability. The theory presented by Mr. Taylor is claimed to yield a law of determined stability of satellites and hence a logical theory for the structure and growth of the solar system.

7. *Metallic Ornaments of the New York Indians;* by W. M. BEAUCHAMP. Pp. 120. Albany, 1903. (New York State Museum, F. J. H. Merrill, Director: Bulletin 73, Archæology 8; Bulletin 305 of the University of the State of New York.)—The number and diversity of Indian ornaments here described will surprise and interest the reader not previously informed on the subject. Upwards of four hundred figures on thirty-seven plates are required for adequate illustration.

8. *Queries in Ethnography;* by A. G. KELLER. 70 pp. (Longmans, Green & Co.)—Professor Keller has prepared an admirable list of queries by use of which observations of travelers and missionaries may be made with such accuracy and pertinency as to be of definite scientific value.

Knowledge Diary and Scientific Handbook for 1904, containing original descriptive articles on the camera applied to science in Astronomy, Microscopy, Natural History; practical work with a small telescope; some uses of the microscope; practical meteorology; the optical constants of lens combinations, and Monthly Astronomical Ephemeris, etc. Pp. 1–420, 85–108. Issued in conjunction with "Knowledge." London (Knowledge Office, 326 High Holborn).

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[FOURTH SERIES.]

ART. XIII.—*The Geology of the North End of the Taconic Range;* by T. NELSON DALE.* (With Plate XI.)

THE Taconic range lies west of the Green Mountain range, and extends from near Fishkill on the Hudson, N.N.E., to a point two miles south of Brandon in Rutland County, Vt., where, geologically speaking, it ends. It consists mainly of schists of Ordovician (Hudson) age, but as its northern part is more or less merged in a hilly belt of Cambrian slate and quartzite, flanking it on the west and extending four miles beyond it, the range may be said, physiographically at least, to extend almost to the Addison-Rutland County line and thus to have a total length of 200 miles.

In the published geological maps the north end of this range has been variously represented: (1) As consisting of a narrow tongue of Cambrian slate extending as far north as Cornwall, bordered on both sides by the schist of the Taconic range, which extends only to Sudbury village on the west and to a point S.W. of Brandon village on the east.†

(2) Of similar constitution but cut off between Whiting and Sudbury by a narrow strip of limestone connecting the limestone of the Vermont Valley with that of Orwell.‡

(3) Of a simple belt of Cambrian shale, etc., extending as far north as Weybridge.§

* Published by permission of the Director of the U. S. Geological Survey.

† Hitchcock and Hager: Report of the Geology of Vermont, vol. ii, pl. i, 1861.

‡ Dana (James D.): An account of the discoveries in Vermont Geology of the Rev. Augustus Wing, this Journal, vol. xiii, 1877. Map opposite p. 334 but modified by explanations on pp. 336, 339, and embodied in another map in vol. xiv, p. 36, in paper by same author entitled: Supplement to the account of the discoveries in Vermont Geology of the Rev. Augustus Wing.

A copy of Mr. Wing's original MSS, kindly loaned to the author of the present paper by Prof. H. M. Seely of Middlebury, contains a sketch map showing the topographic details of this E.-W. strip of limestone.

§ Walcott (Charles D.): The Taconic System of Emmons, and the use of the name Taconic in Geologic nomenclature; this Journal, vol. xxxv, pl. iii, 1888.

The north end of the Taconic range is an important locality, for the principal formations of the Taconic region, the Cambrian slate etc., the Stockbridge Limestone of the valleys, and the Ordovician schists of the Taconic range, all meet there within an area of a few square miles. The topographic map of the Brandon quadrangle, recently finished by the U. S. Geological Survey, has at last made careful exploration of this key locality possible; and the results amply justify the opinion that careful geological mapping with a reliable topographic base is the only method of settling intricate geological problems, and that this mapping should cover large areas, not only to prevent the overlooking of such crucial localities but also to show the wideness of their significance.

The writer and his assistants, Messrs. Louis M. Prindle and Fred H. Moffit, were engaged from 1894 to 1896 in going over and extending Mr. Charles D. Walcott's reconnaissance work in the Slate belt of Washington County, N. Y., and Rutland County, Vt. The results were published in 1899 accompanied by a geological map extending from lat. 43° to 43° 45′, and covering a strip from 10 to 12 miles wide along the west side of the Taconic range, covering in all about 720 square miles.* The fact was there brought out by Mr. Walcott's paleontological data and corroborated by our stratigraphical observations,† that in that region along many miles of intricate geological boundaries, where faulting is out of the question, the Lower Cambrian slates, with their Olenellus fauna, occur in apparently conformable contact with the Ordovician slates, shales, etc., containing Hudson Graptolites. Similarly, the Ordovician schists of the Taconic range were found to be in contact on the west with Lower Cambrian slates along a stretch of 50 miles south of the township of Sudbury, and at only two points (Hubbardton) was there any marked divergence in the strike of the two formations. This involved the anomalous absence of the Stockbridge Limestone along the west foot of that range, whereas on the east side of it the upper part of this formation (of Chazy and Trenton age) dips everywhere conformably under the overlying schists of the Hudson.

During the summer of 1903, the north end of the Taconic range and the adjacent country were somewhat carefully, although not exhaustively, explored by the writer assisted by his son. The exposures were found to be sufficiently numerous to show the mutual relations of the several formations, and the results

* The Slate belt of Eastern New York and Western Vermont, by T. Nelson Dale, 19th Ann. Rept. U. S. Geol. Survey, 1889, Part III, pp. 153–307. Map, pl. xiii. Reviewed in this Journal, vol. clix, p. 382.

† See ibid., pl. xiii and pp. 290–295, on the relation of Cambrian and Ordovician.

are shown in the accompanying map and section, Plate XI.* The map shows a central tongue of Cambrian slate, quartzite, etc., bordered both on the east and west by narrow strips of Ordovician schist or slate, and, in its southern and eastern side, adjacent to a larger mass of Ordovician schist, two miles wide, which constitutes the north end of the Taconic range proper. This tongue of Cambrian is bordered on the north and at several points on the sides by the Stockbridge Limestone. The mass of Ordovician schists, shown at the upper edge of the map, which continues, with a possible interruption east of West Cornwall, 12 miles north to Middlebury and even beyond, is cut off, as was first shown by Wing, from the slate and schist on the south by the Stockbridge Limestone, and is not even indirectly connected, as one of his maps showed, with the Ordovician schists of the Taconic range. The Ordovician part of the Stockbridge Limestone, as shown by fossil localities, touches the Cambrian slates on three sides. The Cambrian part† of that formation, not indicated on the map, crops out near Brandon village, and extends north and east of it, forming a longitudinal belt between the Lower Cambrian quartzite (Vermont Formation) of the Green Mountain range on the east, and the Ordovician part of the Stockbridge Limestone on the west.

The determination of the age of the slates and schists of the north end of the Taconic range is based upon the following evidence: The Lower Cambrian age of the central slate mass in Sudbury is shown by the occurrence at intervals, as far north as the northern slope of Government Hill, a mile east of Sudbury Church, of a slightly ferruginous, calcareous, quartz sandstone, typical of that formation in Washington County, N. Y.;‡ by the fact that typical Lower Cambrian roofing slates are being quarried a half mile north of Stiles Mountain in Sudbury;§ by the presence of six localities of Lower Cambrian fossils in the same belt within two and one-half miles south of the southern edge of the area shown on the map; by the general petrographic charter (massive quartzite, quartzose slates, greenish and purplish roofing slates, calcareous sandstone) of a large part of the area designated as Cambrian. In places, however, petrographic distinctions fail, as the slates become schistose and resemble the Ordovician schist. The Ordovician age of the schist and slate masses bordering the Cambrian (Sh on map) is shown by the presence of red roofing slates, typical of the Hudson,‖ a mile S.S.E. of Hyde

* As to this map: those parts of the geological boundaries which are more or less uncertain are shown in dotted lines to distinguish them from those which are well established and indicated in full lines. The round black dot a half mile E.S.E. of Hyde Manor represents what seems to be an outlier of Ordovician limestone, about 70 × 40 ft. across, resting upon the Cambrian slates.

† Whether this Cambrian includes some Beekmantown is not yet determined.

‡ Horizon E of the slate belt. Op. cit. table facing p. 178.

§ Locality shown on map by crossed hammers.

‖ Horizon Irs of Slate belt. Op. cit. table facing p. 178.

Manor, and three-fifths of a mile E.S.E. of Sudbury Church, and again, apparently, in a badly weathered condition, one and one-fourth mile E.N.E. of Huff pond on the east side of the Cambrian belt; by the presence of typical schists of the Taconic range at the most northern summit of that range, three miles S.S.W. of Brandon village (elevation 1295 ft.); by indications of Ordovician fossils (Crinoid stems, etc.) in a small mass of included limestone, a mile N.N.W. of that hill;* and by the presence of graphitic sericite schist, so common at the base of that schist formation in Vermont and Massachusetts, in the small strip N.E. of Hincum pond. These age determinations are furthermore corroborated by a dominant, though not universal, N.E. strike in the Cambrian slates, and an almost equally prevalent N. or N.15W. or N.N.W. strike in the Ordovician schists and in the underlying limestone.

The structural relations of the formations are shown by symbols on the map and by the section above it, Plate XI. It will be noticed that the parallelism between the strike of the Cambrian and Ordovician, already referred to as characteristic of the slate belt to the south, still persists on the west side of the Cambrian slates near Horton and Burr ponds; but within a mile of Hyde Manor a marked divergence begins to appear, the Cambrian striking more or less N.E., the Ordovician N.15–25W.;† and this continues to the extreme N. end of the mass. The prevalent strike of all the rest of the Cambrian area is about N.E.; exceptionally, however, as east of Huff pond, possibly owing to a minor pitching fold or a small fault, a few N.W. strikes appear, and there may be others. The Ordovician schists of the east side of the Cambrian tongue are likewise marked by a N.15–25W. strike. This, indeed, is the trend and strike of the Taconic range as far south as West Rutland, eleven miles from the south edge of the map. A similar strike also appears in the limestone of the valley towards Brandon. But to this N.N.W. strike of the Ordovician there is also an exception, for the schists of the west side of the schist mass E. and N.E. of Stiles Mountain strike N.E. and a similar strike appears at several points in the limestone embayment east of the Cambrian. The cause of these N.E. strikes in the Ordovician is not apparent, unless it be a system of transverse folds like that occurring on the north end of Mount Anthony in Bennington. A mile N.E. of the Cambrian point the limestone resumes the normal strike of the Green Mountain region, and this recurs again at Leicester Junction, two miles north of the map. To all this should be added that the Cambrian slates have here and there a secondary cleavage foliation, striking N.15W., i. e. parallel to the strike of the bedding of the Ordovician schist.

* Locality marked F on map. † Exceptionally also N.—N.15E.

The section is drawn so as to cross contacts where the unconformity is manifest but owing to insufficiency of data, the folds represented in the Cambrian portion away from the contacts are largely hypothetical. The straightness of the Cambro-Ordovician boundary on the west side may be the result of faulting; but as the unconformity is quite as great at several points on the east side, where faulting is improbable, and as N.E. strikes are quite as characteristic of the center as of the sides of the Cambrian tongue, it is evident that faulting is not the cause of the unconformity. If it exists, it is between rocks which were already unconformable. Such a fault would have to be a reversed one and would hade to the east, bringing the Cambrian beds to overlie the Ordovician ones. The section has been constructed to show the relations without the faulting, although such faulting is regarded as quite possible. That the limestone once covered at least the western border of the Cambrian, is probable from the presence of the small outlier in the Hyde Manor Golf grounds, already referred to and shown in the section. This limestone strikes N.10E., as does also the nearest Ordovician limestone east of it, but the Cambrian slate about it strikes N.40E.

The interpretation of the facts set forth in the map and section is this: The Lower Cambrian slate formation, which is now regarded as the off-shore equivalent of the quartzite of the Green Mountain range (Vermont Formation of U. S. G. S. Monograph XXIII), was folded at the close of Lower Cambrian time and in places, raised above sea level, forming one or more islands in the Champlain oceanic arm. The direction of this Cambrian folding was generally the same as that of Ordovician time, known as the Green Mountain movement, but at this point the axes of these Cambrian folds, for some reason, had a more easterly course, resulting in N.E. strikes. A very gradual depression, beginning during the latter part of Stockbridge Limestone time and continuing into Hudson time, caused the deposition of some of the limestone and of all the schist upon these former islands of Lower Cambrian rocks. This, as suggested to the writer by Professor C. R. Van Hise, resulted in some places in an overlapping of the limestone by the Hudson schist and slate, and in others, in the deposition of the schist and slate immediately upon the Cambrian slates. This overlap, in particular, accounts for the absence of the Stockbridge Limestone for 50 miles along the west side of the Taconic range. In 1898* the writer sought to explain this by a local change from calcareous to argillaceous sedimentation during Stockbridge Limestone time, as had been proven by Pumpelly and

* Op. cit. Slate belt, etc., p. 295, last paragraph, to p. 297.

Wolff to have occurred on Hoosac Mountain.* That explanation of the relations about the Taconic range is now shown to be erroneous.

Then came the Ordovician folding which, here and as far south as West Rutland, produced N.15–25W. strikes, principally, and which may have produced the N.15W. secondary cleavage in the Cambrian slates, and must also have otherwise more or less modified the Cambrian structure as well as the Cambrian surface. The central part of the section shows the Cambrian folding, and the ends of it the overlapping and the Ordovician folding. Denudation through long geological periods must account for the presence of only shred-like remnants of the great mass of Ordovician argillaceous sediments and for the severance of the northern extension of the schist from the Taconic range, and, generally, for the exposure of the Stockbridge Limestone. The salient fact is the unconformity between the Lower Cambrian and the Ordovician, which is masked in the slate region of Washington Co., either by the parallelism in the strike of the two foldings or by the effect of the later one upon the earlier, but which was accentuated at the north end of the Taconic range by the original divergence in the strike of the two periods and is still shown in the dips. This unconformity thus fully corroborates, stratigraphically, the time break shown, paleontologically, by Mr. Walcott's fossil localities.†

Although the Taconic controversy was settled long ago, and has ceased to be of other than historical interest, as it was shown by Dana, Walcott and the authors of Monograph XXIII, that Ordovician rocks had been included by Ebenezer Emmons in his Taconic System owing to the overlooking of faults, the mistaking of cleavage for bedding and insufficient exploration of the areal relations, yet it is remarkable that at this late day it should appear that his contention that there was an extensive formation, marked by a peculiar fauna, now known as Lower Cambrian, unconformably related both to the underlying gneisses (pre-Cambrian) and to the overlying Lower Silurian rocks (Hudson, etc.), should be confirmed, at least for a part of the Taconic region, for no trace of the unconformity shown by this paper has yet been found along the Green Mountain border. During the Taconic controversy, however, conformable succession of the Cambrian and Ordovician beds was supposed by the opponents of Emmons to hold for the entire region.‡

* Geology of the Green Mountains in Massachusetts, by Raphael Pumpelly, J. E. Wolff, and T. Nelson Dale. Monograph, U. S. Geological Survey, XXIII, 1894, pp. 14–18, 104.

† Op. cit. Slate belt, pp. 163, 166.

‡ Rogers (Henry D.), this Journal (1), vol. xlvii, D., p. 152, 1844; Walcott (Charles D.), op. cit. this Journal, vol. xxxv, 1888, p. 320.

Pittsfield, Mass, December, 1903.

ART. XIV. — *Notes on some California Minerals;* by WALDEMAR T. SCHALLER.

HALLOYSITE.

THE pink clay occurring at Branchville, Ct., has been shown* to be montmorillonite, while that occurring at Norway, Me., has proven† to be cimolite. That from the lepidolite mine near Pala, San Diego Co., California, differs from both of the New England clays, being comparable with halloysite.

At Pala, the halloysite occurs in large seams, often several inches thick, and extending many feet in length. The clay is somewhat moist, but quickly dries to a crumbling mass when taken out of the mine. In color it is rather deeper pink than the Norway cimolite and occasionally is somewhat translucent. It readily crumbles to a fine powder when placed in water. The material analyzed had been drying in the air for over three months.

The results of analysis are:

SiO_2	43·62
Al_2O_3	35·55
Fe_2O_3	·21
MnO	·26
CaO	1·02
MgO	·19
Li_2O	·23
Na_2O	·19
K_2O	·03
H_2O (107°)	6·63
H_2O (ab. 107°)	12·25
TiO_2	none
	100·18

The iron was determined as Fe_2O_3, FeO not being tested for. The analysis agrees well with the formula

$$H_4Al_2Si_2O_9+H_2O.$$

AMBLYGONITE.

The occurrence of amblygonite at the lepidolite mine at Pala, California, has already been noticed, and a somewhat fuller description of the mineral is here given. A large deposit has been uncovered and the indications seem to show that it is merely a small part of an extensive body of massive

* This Journal, xx, 283, 1880. † Ibid., xxxii, 355, 1886.

amblygonite. The mineral usually occurs pure; very rarely small amounts of lepidolite are present with it. Frequently broad cleavage faces with irregular outlines can be seen. The color is white and in thin pieces the mineral is translucent. It fuses easily, coloring the flame red, and in powder is difficultly decomposed by sulphuric acid.

An analysis of a specimen kindly presented by Mr. G. F. Kunz gave the writer the following results:

P_2O_5	48·83
Al_2O_3	33·70
Fe_2O_3	·12
MnO	·09
MgO	·31
Li_2O	9·88
Na_2O	·14
H_2O	5·95
F	2·29
TiO_2	none
	101·31
Less O	·96
	100·35

Regarding fluorine and hydroxyl as isomorphous, in the specimen analyzed the latter greatly predominates over the fluorine. The water was determined by igniting the mineral with lead oxide, previously heated nearly to fusion. Three determinations gave the loss of weight, due to the escape of water, as 5·89, 6·01, 5·95 per cent. The loss of the mineral on ignition was 8·03 per cent, equalling the sum of the water and fluorine content.

Boothite.

A specimen of a pale blue copper sulphate was collected at the copper mine near Campo Seco, Calaveras Co., California, by Mr. James Wise, and kindly presented to the writer for investigation. The pale blue color suggested that the mineral might be boothite instead of the more frequently occurring chalcanthite. The results of a chemical analysis have shown that the mineral is boothite, thus affording a second locality for this interesting mineral. Careful quantitative determinations of hydrous copper sulphates will probably show that the heptahydrate is not so rare as may be supposed.

The mineral from Campo Seco occurs massive, showing no crystalline structure. The average of several determinations afforded the following results:

			Ratio.	
CuO	26·13		1·00	
FeO	·81		·03	
MgO	·64		·05	
SO_3	27·25		1·04	
H_2O (110°)	36·76	41·67	6·22	7·06
H_2O (ab. 110°)	4·91		·84	
Insol.	3·96		----	
	100·46			

Formula, $CuSO_4.H_2O+6H_2O$.

A careful determination of the specific gravity of the mineral gave (21° C.) 1·944. This being much lower than the value obtained (2·1) on the boothite from Leona Heights, a redetermination of the latter was made on purer material collected since the publication of the first results.* This gave, as an average value, the figure (22° C.) 1·935. The average of these two determinations, or 1·94, is probably very near the true value for the specific gravity of boothite.

Pisanite.

A small specimen of massive pisanite from Gonzales, Monterey Co., California, was analyzed some time ago and the results are here presented. The quantity of material available for analysis was very small and the determinations do not claim any great accuracy. About 6 per cent of insoluble matter has been deducted and the results recalculated to 100 per cent.

		Ratio.	
CuO	7·56	·27	·89
FeO	15·85	·72	
SO_3	30·74	1·08	
H_2O	45·85	7·18	
	100·00		

The analysis approximates to the formula $CuO.2FeO.3SO_3.21H_2O$.

In the following table, all available analyses of pisanite are tabulated, and one can readily see that there is no definite ratio between the copper and iron. The formula is then written $(Cu,Fe)SO_4.7H_2O$, pisanite being an isomorphous mixture of melanterite and boothite. All the analyses are calculated to 100 per cent.†

* Minerals from Leona Heights, Alamada Co., California, by W. T. Schaller, Bull. Dept. Geol. Univ. of Cal., vol. iii, No. 7.

† Anal. No. 1, theoretical comp. of melanterite, $FeSO_4.7H_2O$; No. 2, Schaller, anal. quoted above; No. 3, Schaller, Bull. Dept. Geol. Univ. of Cal., vol. iii, No. 7; No. 4, Hintz, Zeit. Krys. ii, 309; No. 5, Hillebrand, Bull. U.S.G.S., No. 220, p. 105; No. 6, see No. 3; No. 7, Pisani, Comptes Rendus, 1859, xlviii, 807; No. 8, see No. 3: Nos. 9 and 10, Herz, Zeit. Krys. xxvi, 16; No. 11, theoretical comp. of boothite, $CuSO_4.7H_2O$.

No.	1	2	3	4	5	6
CuO	....	7·56	9·17	10·07	12·61	15·52
FeO	25·86	15·85	16·37	(16·15)	14·14	12·14
SO_3	28·80	30·74	29·00	28·84	28·44	27·82
H_2O	45·34	45·85	45·46	(44·94)	44·81	44·52
	100·00	100·00	100·00	100·00	100·00	100·00

No.	7	8	9	10	11
CuO	15·56	17·45	17·64	18·81	27·85
FeO	10·98	10·18	9·62	8·51	....
SO_3	29·90	28·43	28·27	27·93	28·02
H_2O	43·56	43·94	44·47	44·75	44·13
	100·00	100·00	100·00	100·00	100·00

Quartz Pseudomorph after Apophyllite.

At the Datolite and Pectolite* locality near Fort Point, San Francisco, Cal., a small group of crystals was found which were at first taken to be apophyllite. However, as the crystals proved to be infusible, a more extended investigation of the mineral was made.

The crystals, from one to three mm. in diameter, appear cubic with the corners truncated by small faces. Measurements of the best crystals showed that they are tetragonal and that they agree in angles with those of apophyllite. The forms present are the base, prism of the second order and the unit pyramid of the first order. The prism faces are vertically striated and faces of the other two forms are also rarely somewhat striated.

By trial it was found that hydrochloric acid does not attack the crystals, so the associated calcite was easily removed and pure material for analysis obtained. The crystals are opaque and no optical determinations could be made.

The analysis gave the following figures, showing that the crystals are now, chemically, essentially silica with various impurities.

SiO_2	90·58
Al_2O_3	1·58
CaO	1·87
MgO	2·20
H_2O	4·32
	100·55

* Mineralogical Notes by A. S. Eakle, Bull. Dept. Geol. Univ. Cal., vol. ii, No. 10.

Laboratory of the U. S. Geological Survey, November.

ART. XV. — *Crystallographical and Chemical Notes on Lawsonite;* by W. T. SCHALLER and W. F. HILLEBRAND.

CRYSTALS of lawsonite are very simple in their combinations, the common forms being the prism, base and brachydome. Two habits occur; tabular crystals with {001} and {110} and crystals with the forms {110} and {011}. The brachypinacoid and the brachydome {041} also occur. A large number of crystals from the typical locality in Marin County, California, were collected by the writer and carefully examined with a hand lens for any additional forms. Only two new forms were determined.

The forms observed on the six crystals measured are:

$c = 0 \ = 001$	$d = 01 = 011$
$b = 0\infty = 010$	$e = 04 = 041$
$m = \infty \ = 110$	$r = \ 2 = 221$
	$s = \ 3 = 331$

The angles measured, with those calculated for these forms, are quoted in the table following:

No.	Letter.	Symbol. Gdt.	Symbol. Miller.	Measured. ϕ	Measured. ρ	Calculated. ϕ	Calculated. ρ
1	*c*	0	001	....	0° 02′	....	0° 00′
2	*b*	0∞	010	0° 00′	90 00	0° 00′	90 00
3	*m*	∞	110	56 22	"	56 22	"
4	*d*	01	011	0 09	36 36	0 00	36 27
5	*e*	04	041	0 00	71 18	"	71 18
6	*r*	2	221	56 27	69 10	56 22	69 27
7	*s*	3	331	56 22	76 21	"	75 58

The new pyramid $r = 2 =$ {221} is present on two crystals, the faces giving good reflections. Fig. 1 shows one crystal on which this form occurs.

The new pyramid $s = 3 =$ {331} is present on only one crystal and but one face of the form occurs. The relative size of the face is about the same as that of the preceding pyramid. The reflection was fair.

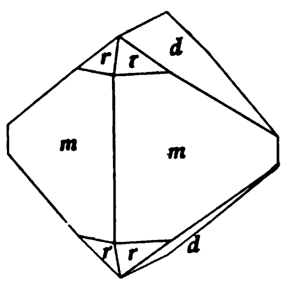
The brachydomes are usually deeply striated, rendering it difficult to determine with certainty any domes present. On two crystals, reflections were obtained from two faces, measurements of which agree with the angles calculated for the form {034}. The form is rather uncertain and is not included with the others.

Measured.		Calculated.	
ϕ	ρ	ϕ	ρ
0° 23′	28° 07′ —14′	0° 00′	28° 59′
0 00	28 07		

The combinations observed on the crystals measured are shown in the following table:

Cryst. No.	*c*	*b*	*m*	*d*	*e*	*r*	*s*
1	..	..	*m*	*d*	..	*r*	..
2	..	*b*	*m*	*d*	..	..	*s*
3	..	..	*m*	*d*	..	*r*	..
4	*c*	*b*	*m*	*d*	*e*	..	..
5	..	*b*	*m*	*d*	..	..	..
6	*c*	..	*m*	*d*	*e*	..	..

1



The following table is a calculation of the two new forms corresponding to the tables given in Goldschmidt's Winkeltabellen.

No.	Letter	Symbol	Miller	ϕ	ρ	ξ_0	η_0	ξ	η	x (Prism) ($x:y$)	y	$d = tg\,\rho$
6	*r*	2	221	56° 22′	69° 27′	65° 45′	55° 54′	51° 13′	31° 14′	2·2204	1·4770	2·66
7	*s*	3	331	"	75 58	73 17	65 42	58 53	32 30	3·3306	2·2155	4·00

Material carefully purified by the Thoulet solution followed by repeated electromagnetic extraction, and having then a specific gravity of 3·121 at 25°, gave the following results of analysis:*

* Concerning this purified material, Dr. Ransome reports as follows: "I should say the material is as pure as it is possible to get it. The grains are all lawsonite, but vary in individual purity. Some are perfectly clear. Others have minute inclusions, which appear in most cases to be solid particles but are too minute for identification. One of them, however, was suggestive of rutile. Some of the grains are slightly clouded with a yellowish stain which the microscope is unable to resolve into distinct particles. There are apparently a few fluid inclusions also."

		Mol. Ratio	Calc. for the formula $H_4CaAl_2Si_2O_{10}$
SiO_2	38·45	1·98	38·34
TiO_2	0·38		
Al_2O_3	31·35	0·97	32·44
Fe_2O_3	0·86		
FeO	0·10	1·00	17·80
MnO	faint trace		
CaO	17·52		
MgO	0·17		
K_2O	0·23		
Na_2O	0·06		
H_2O (ignition)	11·21	1·95	11·42
	100·33		100·00

Titanium is not considered in the ratio because probably present as an inclusion of rutile or titanite. If the latter, the ratio would perhaps approximate still more closely to the theoretical than it does. The agreement with the formula deduced by Ransome and Palache from their rather widely differing analyses is very satisfactory. The behavior of the mineral before the blowpipe is somewhat different from that given by those authors, or rather their statement needs amplification. On first applying the flame, a splinter appears to fuse easily as stated, and there is formed a blebby glass, or on larger splinters a porous sinter, but this fusing is only momentary, and it requires the highest heat attainable, under which the fragment emits quite an intense light, to produce a further softening and rounding of the edges. If a rather large splinter is held in the flame of the blowpipe, or in a small flame of a blast lamp, a very sudden and marked exfoliation is observed, but even the extruded points and edges do not fuse completely in the highest attainable heat. The semi-fused surface, however, appears on cooling dark and sometimes nearly black where the heat was most intense. If care is taken, in producing this exfoliation, to apply the flame but for a moment, it has been noticed that a singularly shaped excrescence may shoot out from a point of the surface.

Laboratory of the U. S. Geological Survey, November.

Art. XVI.—*A Determination of Nitrites in Absence of Air*; by I. K. Phelps.

[Contributions from the Kent Chemical Laboratory of Yale University—CXXIV.]

Dunsten and Dymond* have recommended the use of an evacuated flask for the estimation of nitrites by the action of potassium iodide in acid solution. Under these conditions, the nitrous and hydriodic acids interact to produce nitric oxide (which must be kept from contact with gaseous oxygen) and iodine which is determined by decinormal sodium thiosulphate. As objections to the process may be cited the necessity of getting an absolutely gas-tight, rubber-jointed apparatus and the restriction put upon the size of the flask by the two considerations of withstanding the atmospheric pressure when evacuated and yet being thin-walled enough to allow of the ready heating of the flask. A practical test of a slight modification of the device already used in the determination of nitric acid† for getting an inert atmosphere proves to obviate these difficulties and to leave little to be desired in point of accuracy.

The apparatus used was the same as in the estimation of nitric acid already referred to above. It consisted of a boiling flask of 250^{cm^3} capacity closed with a rubber stopper carrying in its two perforations the inlet and exit tubes. A stoppered funnel of 50^{cm^3} capacity with its tube constricted at its lower end was used as an inlet tube; and a glass tube of $\cdot 8^{cm}$ internal diameter, enlarged just above the stopper to a small bulb (to prevent mechanical loss of the solid contents of the flask during the boiling) and bent twice at right angles, served as an exit tube. The flask was supported in the usual manner at a convenient height to allow of heating with a Bunsen burner placed beneath and the exit tube was made of a sufficient length to reach to the surface of some mercury contained in a test tube to the depth of about three centimeters.

The analysis was made as follows: An amount of standard arsenious acid solution, slightly in excess of that required to take up the iodine to be set free later by the nitrous acid, and 25^{cm^3} of a concentrated solution of sodium carbonate were placed in the flask. The stem of the dropping funnel was completely filled with water, the rubber stopper inserted tightly, and the contents of the flask boiled until all air was expelled—a process requiring an active boiling of 5–8 minutes. The flame was then removed, the exit tube plunged deep into the mercury by changing the position of the flask on its wire gauze—which is particularly easy if the gauze is well depressed at

* Pharm. Jour. [3], 19, 741.　　† This Journal, xiv, 440 (1902).

the center and the flask placed well up on the higher part in the preceding operation—and sulphuric acid (1–4) sucked in through the funnel tube as the flask cooled, the cooling to the room temperature being hastened by standing the flask in a dish containing ice and water. In all, 7^{cm^3} of sulphuric acid were added, this amount having been found by previous experiment to be nearly but not quite enough to neutralize the sodium carbonate used and also having been found to yield a little more carbon dioxide than the apparatus can hold at the atmospheric pressure. As soon as the diminished pressure in the apparatus was too weak to suck in the acid, the position of the flask was again changed on the wire gauze so that the exit tube was raised out of the mercury into the layer of water which had condensed during the preceding boiling and which then served to trap the apparatus from the outside air. After the acid had been added and had been washed in carefully, the nitrite solution to be analyzed containing 2 grms. of pure potassium iodine was introduced into the flask through the funnel and this was followed by sulphuric acid (1–4) in sufficient amount (5^{cm^3}) to render the contents of the flask acid in reaction. Potassium bicarbonate was then added in concentrated solution to alkaline reaction or until the free iodine had been taken up, the mixture boiled for about five minutes to expel the nitrogen dioxide, cooled, and titrated to color with decinormal iodine in the presence of starch paste. In making the various additions of liquid to the flask, care was necessarily taken that no air was introduced with the liquid. Table I records experiments made in this manner upon a solution of commercial sodium nitrite, standardized by treatment with potassium permanganate and oxalic acid in acid solution according to the procedure of Kinnicut and Nef.*

TABLE I.

	$NaNO_2$ taken. grm.	Oxygen value of As_2O_3 taken. grm.	Oxygen value of As_2O_3 found. grm.	Error on Oxygen. grm.	Error on $NaNO_2$. grm.
1	0·0958	0·01200	0·00064	0·00025 +	0·0011 +
2	0·0958	0·01200	0·00066	0·00024 +	0·0010 +
3	0·1916	0·03200	0·00965	0·00017 +	0·0007 +
4	0·1916	0·03200	0·00965	0·00017 +	0·0007 +
5	0·3832	0·05600	0·01120	0·00043 +	0·0018 +
6	0·3832	0·05600	0·01118	0·00045 +	0·0019 +
7	0·6716	0·08000	0·00160	0·00076 +	0·0033 +
8	0·6716	0·08000	0·00158	0·00078 +	0·0034 +
9	0·1916	0·03280	0·01003	0·00062 +	0·0027 +

* Amer. Chem. Jour., v, 388 (1883).

The experiment numbered 9 is included to show a fact found early in the investigation, namely, the necessity of boiling out the nitrogen dioxide before titrating the residual arsenious acid. It was made like 3 and 4 above up to that point, when in stead of boiling out the nitrogen dioxide, cooling, and titrating, it was treated with a slow stream of air bubbling through for fifteen minutes and then titrated. Evidently the nitrogen dioxide in oxidizing affects the arsenious acid slightly.

When the sulphuric acid is being added to the alkaline solution containing the arsenite, iodide, and nitrite, iodine is set free locally but is at once taken up by the alkaline arsenite, so that finally, when the acid reaction is reached, there is only a small amount of it free, no matter how much nitrite may have been used. This condition reduces to a minimum the possibility of a loss of iodine by volatilization.

As might be anticipated, the two processes show slightly different results, the process outlined above tending to give results in excess of the theory on account of the action of dissolved oxygen, while that of Kinnicut and Nef should show a deficiency as compared with theory, since the loss of nitrogen oxides is evidenced by the odor when even a very dilute solution of a nitrite is acidified.

ART. XVII.—*The Use of Ferrous Sulphate in the Estimation of Chlorates and Bromates*; by I. K. PHELPS.

[Contributions from the Kent Chemical Laboratory of Yale University—CXXV.]

IN a recent article,* a method for the titrimetric estimation of nitric acid or nitrates was described. It consisted, briefly, in the measurement of the amount of ferrous salt oxidized in the reduction of the nitric acid to nitric oxide by an excess of ferrous sulphate in the presence of hydrochloric acid. The value of ferrous sulphate as a reducing agent in analytical processes has been long recognized on account of its ready availability, the high degree of precision with which it may be determined, and the extreme slowness with which it is oxidized by atmospheric oxygen. This last fact was clearly shown by Peters and Moody† for solutions which had been allowed to stand until all active oxygen, dissolved in the water, or otherwise present, had produced its effect. The author was surprised to find that, in boiling such solutions in the open air and cooling with stirring in running water, no distinctly perceptible change could be noted, although the oxidation from day to day was plainly evident.

Carot‡ has suggested the use of ferrous sulphate for determining the oxygen in hypochlorites and chlorates in admixture with chlorides but gives no evidence to show the degree of accuracy of the process. Table I records experiments made with the purest potassium chlorate of commerce to test this point. The dry salt was weighed out, treated with an excess of standardized ferrous sulphate solution $\left(\text{approximately } \frac{n}{5}\right)$, and with 15^{cm^3} of sulphuric acid (1 : 4). This mixture was brought to the boiling point in a trapped flask, cooled to room temperature by immersion in running water, diluted to a volume of 600^{cm^3}, and, after the addition of 1–2 grms. of manganous chloride, titrated to color with standard potassium permanganate solution.

TABLE I.

$KClO_3$ taken. grm.	Oxygen value of ferrous salt taken. grm.	Oxygen value of ferrous salt found. grm.	Error on $KClO_3$. grm.
0·0500	0·02756	0·00814	0·0004 —
0·0500	0·02739	0·00781	0·0000 ±
0·1000	0·04934	0·01024	0·0002 —
0·1000	0·04951	0·01043	0·0002 —
0·2000	0·09086	0·01247	0·0002 +
0·2000	0·09078	0·01277	0·0008 —
0·5000	0·20552	0·00993	0·0006 —
0·5000	0·20543	0·00980	0·0005 —

* This Journal, xiv, 440 (1902). † This Journal, xii, 369 (1901).
‡ Compt. Rend., cxxii, 449.

Table II records similarly experiments made upon a sample of thrice crystallized potassium bromate which was prepared by acting on potassium hydroxide with bromine evolved from pure potassium bromide by sulphuric acid and manganese dioxide. The experiments were performed like those with the chlorate, described above, except that the excess of ferrous salt used in the reduction was determined by decinormal iodine in alkaline solution instead of by permanganate in acid solution. The solution was cooled after boiling, was nearly neutralized with a concentrated solution of sodium carbonate, and was then treated with 2–3 grms. of Rochelle salt in solution and an excess of decinormal iodine solution. The mixture was made alkaline with an excess of potassium bicarbonate solution, starch paste added, the starch blue bleached with decinormal arsenious acid, and, finally, the excess of this last titrated to color with iodine.

TABLE II.

$KBrO_3$ taken. grm.	Oxygen value of ferrous salt taken. grm.	Oxygen value of ferrous salt found. grm.	Error on $KBrO_3$. grm.
0·0500	0·01776	0·00357	0·0006 —
0·0500	0·01770	0·00336	0·0001 —
0·1000	0·03792	0·00942	0·0008 —
0·1000	0·03792	0·00922	0·0001 —
0·2000	0·06321	0·00576	0·0000 ±
0·2000	0·06321	0·00580	0·0002 —
0·5000	0·15670	0·01342	0·0013 —
0·5000	0·16212	0·01870	0·0008 —

An inspection of the results shows that the processes may be justly considered as accurate for analytical purposes—especially so when one considers that they measure only the oxygen in the salt analyzed, which is 39 per cent for potassium chlorate and 28 per cent for potassium bromate.

ART. XVIII.—*Studies of Eocene Mammalia in the Marsh Collection, Peabody Museum;* by J. L. WORTMAN.

[Continued from vol. xvii, p. 140.]

On the Affinities of the Omomyinæ.

As I have already fully stated, my arrangement of this group of Primates under the Paleopithecine division of the Anthropoidea is only provisional. The incompleteness and frag-

135

136

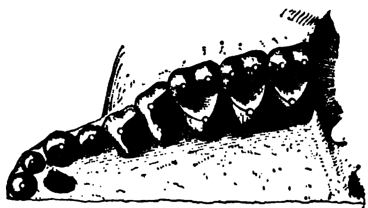


FIGURE 135.—Lower jaw of *Tarsius spectrum;* crown view; two and one-half times natural size.
FIGURE 136.—Upper teeth of *Tarsius spectrum;* crown view; two and one-half times natural size.

mentary condition of the remains of all the species thus far known precludes the possibility of determining their affinities and position with any great degree of exactness. It has been pointed out that the dentition of the lower jaw, and presumably that of the upper jaw also, in all the species in which it is definitely known, is represented by two incisors, a canine, three premolars, and three molars. This number differs from that of *Tarsius*, figure 135, in the presence of an additional incisor, there being only a single pair in the lower jaw of that genus. The structure of the lower molars and premolars accords well, moreover, with that of *Tarsius*, which undoubtedly represents a very generalized pattern among the Primates, and one from which it is possible to derive all the more complex types of the higher forms. In the structure of the superior molars, all the species of the Omomyinæ have apparently advanced beyond

the *Tarsius* stage, figure 136. This is seen in the continuation of the cingulum forward, around the internal face of the crown, and the development of a distinct cingular cuspule internal to the main antero-internal cusp. In the two external roots of the fourth superior premolars, however, the species of the Omomyinæ, as far as known, agree with *Tarsius*. This is very probably a generalized character, also, since there is very strong presumptive evidence that the single external root of the third and fourth premolars, common in the higher apes, is the result of degeneration caused by the shortening of the face.*

137 138

Figures 137, 138.—Upper and lower teeth of *Cebus apella;* crown view; three halves natural size.

The final determination of the exact relations of these forms to *Tarsius* must await the discovery of the lachrymal region, as well as of the structure of the limbs and feet.

It is proper, however, to call attention in this connection to some striking resemblances which this group exhibits to certain of the South American apes, notably the capuchins and squirrel monkeys. In the former of these, of which *Cebus apella*, figures 137 and 138, is a good example, the upper molars present a characteristic and in many respects a peculiar and distinctive pattern. The first molar is the largest of the series

* In *Cebus* the external root of the third and fourth premolars is either deeply grooved or completely divided at the end. This is likewise true of *Mycetes*, as well as of many species of Old World apes. An example of the fusion of the external roots is seen in the last molar of many species of apes where it is strongly reduced, as in *Cebus*, *Chrysothrix*, and others.

and the last is the smallest, being considerably reduced. In the crowns of the first and second, the trigonal ridges are distinct, and there is a prominent intermediate cusp present. The postero-internal cusp is well developed and has a position much more internal to the antero-internal than is generally the case in molars of the higher Primates. Because of its position this cusp is more widely separated than usual from, and does not develop a close connection with, the original trigon. There is a strong cingulum continued forward around the inner face of the crown, from which a small cingular cuspule is formed internal to the main antero-internal cusp. This is most dis-

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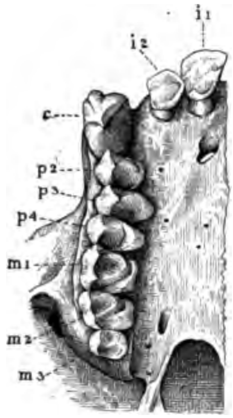

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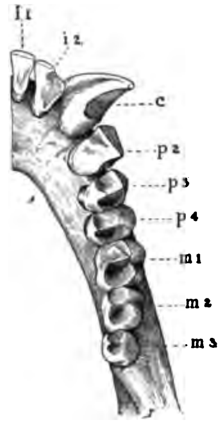

FIGURES 139, 140.—Upper and lower teeth of *Chrysothrix sciurea;* crown views; twice natural size.

tinct in the second molar, although a considerable rudiment of it is seen in the first. In the squirrel monkey, *Chrysothrix sciurea*, figures 139, 140, and 141, the superior molars exhibit practically the same structure as those of *Cebus*, the only important difference between the two being that the posterior intermediate cusp is not distinct in *Chrysothrix*. The cingulum is continued around the inner face of the crown in both the first and second molars in the same way as it is in *Cebus;* but its development is greater in the first molar than in the second, whereas in *Cebus* the cingulum and the anterior cingular cusp are stronger in the second than in the first.

This peculiarity in the structure of the molars is not found in any other South American ape, nor, as far as I am aware, in any other living species of Primate in any part of the world. It is highly significant, therefore, that so unusual a modification and one so entirely unique among the Primates should be

met with in its incipient stages in the typical North American Eocene group Omomyinæ. As we have just seen, this character is found in the upper molars of all the species, and may be said to be especially characteristic of them. We know, moreover, that they are Primates; that the dental formula for the lower jaw and presumably for the upper is the same as in the Cebidæ; that the number, structure, and relations of all the teeth of certain species, at least, so completely fulfil the requirements and conditions which one would naturally seek in an ancestor of these living Cebidæ, as to make it scarcely possible to believe that such striking resemblances can be altogether accidental. In fact, this is the only group of Primates that has ever been found, among either living or extinct forms outside of South America, which exhibits any approximation to any of the Cebidæ, and until some tangible evidence to the

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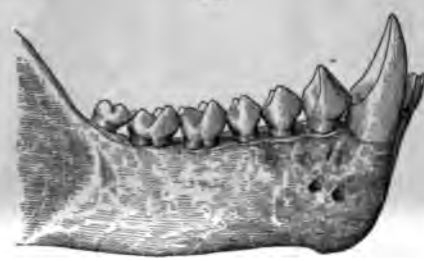

FIGURE 141.—Lower jaw of *Chrysothrix sciurea*; side view; twice natural size.

contrary is forthcoming we are compelled to regard these extinct North American types as the source from which the ape fauna of the Neotropical realm had its origin.

It has been assumed by some who have sought to solve the problem of the origin of the Cebidæ, that they were derived from Africa, and making their way thence across an Antarctic land connection, thus reached South America. This view is based upon the presence in the Patagonian Miocene of the remains of numerous Marsupials closely allied to those now living in Australia, which argues strongly for a land connection with that continent during the Tertiary. From resemblances among certain living species from South America to those of Africa, as well as among some of the extinct forms, it is further assumed that this land bridge extended to Africa, and that there was an interchange of species between the two Hemispheres. While this may perhaps satisfactorily account for the presence of those African types in South America, it does not

apply to its simian population. The insuperable objection to an African origin for the Cebidæ is found in the complete absence of any group of Primates, either fossil or recent, in the tropics or any part of the Eastern Hemisphere, which exhibits any near affinities with the New World apes. Africa is to-day the congenial home of a large and varied lemuroid and simian population in which species of the highest and lowest degree exist side by side. Something is known, moreover, of the ancient representatives of this Primate fauna from the Tertiaries of Europe and Asia, but whether we consider the living or extinct forms, not a single species has yet been brought to light among them which does not proclaim its distinctive relationship and bear the unmistakable stamp of its affinities with the Primates of the Old World. Among the monkeys and apes, this is so positive that no one has ever ventured to assert the contrary.

In like manner, the fossil monkeys of South America exhibit the closest relations to those species now living there. Ameghino has found the remains of apes in the Santa Cruz Miocene of Patagonia, which are closely allied to, and hardly distinguishable from, the living *Cebus* of the Amazonian tropics. They exhibit no traces of relationship with any species inhabiting Africa. Any direct connection between the Cercopithecidæ and the Cebidæ may be dismissed, therefore, as utterly untenable and unsupported by a single fragment or vestige of evidence. Neither can it be logically argued that the Cebidæ, originating in Africa, migrated thence in a body to the New World. No assignable reason can be given why all the genera, species, and individuals of so large and varied an assemblage as the New World apes must have been, even prior to the Miocene, should have suddenly quitted the home of their birth, without leaving behind a single representative or trace which would furnish a clue to their former presence in a region now so well fitted, apparently, for ape existence. Any such vestige, however, is singularly absent, and from whatever point of view we choose to regard it, such a hypothesis appears simply impossible.

In connection with the evidence which I have already brought forward in favor of the North American origin of the Edentata,* a similar origin for the South American Primates, which is the only alternative hypothesis conceivable, is placed upon an extremely probable, if not absolutely secure, foundation, and is entitled to infinitely greater consideration than any purely conjectural origin of these forms, wholly without evidence in its support. I have formerly suggested that the so-called Litopterna were direct derivatives of *Meniscotherium* of our Wasatch

* The Ganodonta and their Relationship to the Edentata, Bull. Amer. Mus. Nat. Hist., vol. ix, pp. 59–110, 1897.

beds, and I now further venture to believe that all the South American Ungulates, including the Toxodonts, Typotheres, Astrapotheres, etc., are but modified descendants of our North American Condylarths, and were derived from the same region as the Edentates and Primates.

Subfamily Anaptomorphinæ.

As already indicated, the genera of this subfamily agree in having only eight teeth in the lower jaw. It is in all probability not a natural assemblage, since it is tolerably clear that the missing teeth are not the same in the various genera. Until this is more fully determined by better specimens, the present classification must be regarded as by no means final. The genera composing this group can be distinguished by the following characters:

Lower molars having four cusps on trigon, all distinct; heel of last molar with four cusps; first and second molars not especially wider behind than in front; last molar largest of the series; fourth lower premolar with moderately strong internal cusp and rudimental heel; third premolar with very small rudiment of internal cusp; canine larger than second premolar or incisor; only one pair of incisors in lower jaw (?); superior molars tritubercular, with more or less rectangular outline; intermediate cusps small, but distinct; postero-internal cusp well developed on crown of first and second molars, but not distinct on third.
Washakius.

Lower molars having only two cusps on trigon; last molar unknown in type; first and second molars widening rapidly behind; third and fourth lower premolars without internal cusps; canine larger than incisors; second premolar absent in type; two pairs of incisors in lower jaw; upper teeth unknown in type.
Anaptomorphus.

Lower molars having only two cusps on trigon, a vestigial anterior cusp on first; heel of last molar with three cusps; first and second molars wider behind than in front; last molar not reduced; fourth lower premolar with well-developed internal cusp; second tooth of the series vestigial and implanted external to the tooth line; superior molars quadritubercular.
Necrolemur.

Washakius insignis Leidy.

Washakius insignis Leidy, Contr. Ext. Fauna West. Terr., 1873, p. 123.

Leidy's type of this genus and species consists of a fragment of a lower jaw carrying the second and third molars so much worn as not to display the arrangement of the cusps. Up to the present, this specimen has remained the sole example of the species, which on account of its imperfect representation

has had no very definite standing. Its relationship to the Primates, even, has been called in question, and it has been thought by some to belong to the Rodentia. There are, however, about ten individuals represented in the Marsh collection, which I do not hesitate to refer to Leidy's genus and species. The most conclusive point in this identification is found in the extra cusp on the inner posterior surface of the trigon of the lower molars, the remains of which can be still plainly seen in the much-worn molars of Leidy's type. In one specimen in the Marsh collection, there is in association with the lower teeth a fragment of an upper jaw containing two molars, so that the structure of the teeth can be made out with a reasonable degree of accuracy.

The complete dental formula of the lower jaw is not known with absolute certainty, but in one specimen the front of the jaw is sufficiently preserved to render it highly probable that there was but a single pair of incisors. At all events, if the

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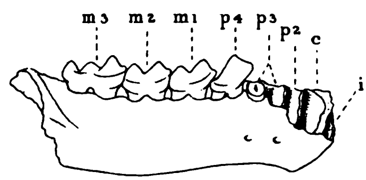

FIGURE 142.—Right lower jaw of *Washakius insignis* Leidy; side view; two and one-half times natural size; drawn from two specimens.

middle incisors were present they must have been exceedingly small. A good idea of the relations of the lower teeth can be had from the accompanying illustration, figure 142, which was drawn from two specimens. The outer side of the front of the jaw is injured so that the lower part only of the alveolus for the incisor is shown; this is seen to be smaller than that for the canine. Following this without diastema is a small alveolus for the second premolar, after which come the double-rooted third and fourth premolars. The crown of the second, figure 143, has a simple pointed summit, to which is added a small anterior basal, and a stronger internal cusp. That of the second has a similar structure but the internal cusp is better developed. In both the third and fourth premolars, the internal cusp is placed rather low upon the crown. The heel is rudimental.

The molars are peculiar in the composition of their crowns, by reason of the possession of an extra cusp situated internal and a little posterior to the main antero-internal cusp. The trigon thus has four cusps, a condition unknown in any other species of Primate. The remaining cusps of the trigon are

normal in their relations to the crown, the anterior one being distinct in all the molars. The heel of the first and second molars has the usual two cusps and is but little wider than the anterior portion or trigon. In the last molar, however, the heel has four cusps, which is again a unique character among

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FIGURE 143.—Left lower jaw of *Washakius insignis* Leidy; inside and crown views; two and one-half times natural size; drawn from two specimens.

FIGURE 144.—Last left lower molar of *Washakius insignis* Leidy; crown view; five times natural size.

the Primates. An outline view of the grinding surface of the crown of the last lower molar of the left side, enlarged five times, is given in figure 144, which represents accurately the arrangement of the cusps. The enamel of the crowns of all

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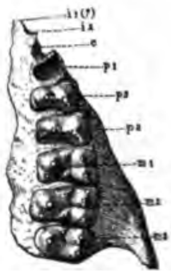

FIGURE 145.—Last two superior molars of the right side of *Washakius insignis* Leidy; crown view; four times natural size.

The postero-internal cusp of the second molar is not represented strong enough in the drawing.

FIGURE 146.—Left superior maxillary of *Washakius insignis* Leidy; crown view; two and one-half times natural size.

the lower teeth is strongly wrinkled, that occupying the valley of the heel especially so.

The fragment of upper jaw associated with the lower teeth, figure 145, contains the second and third molars. The second molar is larger than the third, although the disparity in size is not so great as in *Omomys* or *Hemiacodon*. The crowns are

tritubercular, with only a moderate development of the postero-internal cusp, and the cingulum is not continued forward around the internal face of the crown and does not develop the internal cingular cuspule seen in *Omomys* and *Hemiacodon*. The outer cusps are slightly flattened externally, and the intermediates are moderately developed. The enamel is much wrinkled, particularly that upon the inner portion of the crown. A second specimen, representing upper teeth, consists of a large part of the superior maxilla containing all the molars and the third and fourth premolars, figure 146. It also exhibits the alveoli of the second premolar, canine, and probably two incisors; that of the first incisor is, however, very indistinct, and one can not be sure that it was actually present.* In this specimen the second molar is larger than either the first or third, which are subequal. The postero-internal cusp is more distinct in the first molar than in the second or third. The premolars display single external and internal cusps, with a strong postero-internal cingulum tending to the formation of an additional cusp. The canine, as indicated by the size of the alveolus, is larger than the outer incisor or second premolar, and, as in the lower jaw, the teeth were implanted in a continuous row. The infraorbital foramen is single and issues above the anterior border of the third premolar in the same relative position as in *Hemiacodon*. The malar did not reach the lachrymal, thus leaving the maxillary a large share in the anterior boundary of the orbit, which was enlarged.

From these many resemblances to the Primates, there can not apparently be any question of the affinities of the genus, notwithstanding the peculiarities of the structure of the lower molars. It seems to have left no modified descendants, however, in the existing fauna.

Anaptomorphus æmulus Cope.

Anaptomorphus æmulus Cope, Proc. Amer. Philos. Soc., October, 1872 p. 554.

This genus and species were proposed by Cope upon the greater portion of a left mandibular ramus now preserved in the American Museum collection, which, as far as I am aware, is the only specimen of this species known. The jaw carries the first and second molars and the fourth premolar, together with the alveoli for all the remaining teeth, eight in all. The formula has been generally considered to be two incisors, a

* That which leads me to suspect the presence of two incisors in the upper series is the sharp inward curvature of the lower jaw near the symphysis, giving a greater transverse width in this region of the mouth. There would thus be a considerable gap left between the outer incisors and the median line. I think there can be little doubt that this space was occupied by a central pair of incisors.

canine, two premolars, and three molars, principally for the reason that the alveolus for the third tooth is enlarged after the manner of a canine, while the two in advance of it are small and hence have been thought to represent incisors. This determination is very probably correct, but it can not be accepted as final until the upper teeth are fully known. The extreme reduction in the number of premolars is a condition more advanced than that found in any other species of Primate, either living or extinct, in the Western Hemisphere; and that it should have taken place as early as the Eocene is indeed remarkable. In agreement with this reduction, it may be noted, however, that the structure of the lower molars is further advanced than that of any of its contemporaries in the Bridger. This is seen in the loss of the anterior cusp of the trigon from all the molars, and their consequent reduction to the four-cusped stage. I have already called attention to certain resemblances in the structure of the molars between *Anaptomorphus* and *Euryacodon*, but the former exhibits a greater advance in the modification of these teeth.

A second species, *A. homunculus*, was described by Cope from the now famous cranium found by me in the Basin of the Big Horn, in 1881. This cranium, together with a second specimen (No. 41 of the American Museum collection) which I also discovered in 1891, in the same region, has recently been refigured by Osborn.* These drawings are beautifully executed, but it is to be regretted that the skull is represented as complete in front, which is by no means the case. Osborn's figure gives the impression that the face is as much shortened and as reduced as in the highest type of living ape. Cope's original figure, in his Tertiary Vertebrata, is far more accurate in that it represents the entire anterior portion of the skull as missing. After a most careful study of the remains of this species in the American Museum collection, I find myself unable to agree with Cope in regard to the dentition of the cranium in question, or with Osborn concerning the dentition of the additional specimens. Cope determined the premolar dentition of the upper jaw to be two, and Osborn gives the number of lower premolars as three. The facts may be briefly stated as follows: In the cranium, there is evidence of the presence of seven teeth; of these, three are undoubtedly molars, and the remainder incisors, canine, and premolars; the most anterior tooth indicated is represented by an alveolus; the next is a pointed single-rooted tooth separated by a short diastema from those behind; the two following teeth are undoubtedly premolars, with single external and internal cusps.

* American Eocene Primates, Bull. Amer. Mus. Nat. Hist., 1902, p. 200.

[The element of uncertainty comes in the determination of nature of the first two teeth, and I can find no proof that the gle pointed tooth is the canine, as held by Cope and Osborn. ere is certainly no indication of the maxillo-premaxillary ure to be found, and the tooth in question may quite as well a premolar as a canine. In fact, in the fragmentary maxilla the other specimen (No. 41) there is evidence of a tooth h more than a single root in advance of the two premolars, l if the two specimens belong to the same species, which is re than likely, there were certainly three premolars in upper jaw. In like manner I am unable to discover any iclusive evidence in favor of Osborn's statement that there three premolars in the lower jaw, together with a canine l two incisors. I am strongly inclined to believe that re were three premolars in the lower jaw, however, and that born's determination is correct; but at the same time the cimens are not sufficiently perfect to furnish conclusive of of the fact. Nor can it be demonstrated at the present ie that the Big Horn and the Bridger species belong to the ne genus. Upon general considerations, I think it most likely. I believe, moreover, that the Big Horn species is a e with three premolars above and below, and that it is gencally distinct from the Bridger *Anaptomorphus*. I have rained from proposing a new genus for this species, preferg to let the matter rest until the dentition of both the Big rn and the Bridger forms is more fully known.

In the matter of the restoration of the skull, I can find no rrant for the extremely abbreviated face which Osborn gives his drawing. The contour of the muzzle was undoubtedly ich more like that of *Tarsius*, with which the cranial anaty so closely agrees. Apparently very little consideration been given to these resemblances between *Tarsius* and the Horn fossil, which Cope pointed out. It will perhaps be ll to recall them here, with some emendations and additions. ey are as follows: (1) The species are of about the same e, both being small; (2) the brain development is relatively ge; (3) the brain projects well backward beyond the foran magnum, so as to overhang the occiput; (4) there is no ittal crest; (5) the face is considerably shortened, and the its are large; (6) the canal for the internal carotid pierces petro-tympanic; (7) the dentition is very probably the same, th the exception of the loss of one pair of incisors in the ver jaw in *Tarsius;* (8) the structure of the molars and prelars is very similar; (9) the bullæ are much inflated, and the ternal wings of the pterygoids extend backward, so as parlly to enclose the bullæ externally; (10) the lachrymal tends out upon the face, and the opening of the lachrymal

canal is external to the orbit; (11) although not positively known, the relations of the lachrymal and malar are the same.

There are some differences to be noted, but they relate entirely to the assumption of modernized features on the part of *Tarsius*. Upon the whole, the resemblances are so striking and strongly marked that apparently there can not be the slightest question, not only of the close relationship between the two forms, but of the further important fact of their common origin. I have already suggested that the place of this origin was within an ancient circumpolar land.

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FIGURE 147.—Right lower jaw of *Necrolemur Edwardsi* Filhol; enlarged several times. (After Filhol.)
FIGURE 148.—Three lower molars of *Necrolemur Edwardsi* Filhol; crown view; enlarged. (After Filhol.)

Necrolemur may or may not belong in this series. If it does, it is by no means as closely allied to *Tarsius* as the American species. It has been suggested by Leche that it is related to the Indrisine lemurs, and there is indeed much in favor of such a view. If one compares the lower jaw of *Necrolemur Edwardsi*, figure 147, with that of *Propithecus diadema*, the resemblance in general form is at once apparent. The loss of the vestigial second tooth in *Necrolemur* would give the formula of the Indrisinæ, which is seven teeth in the lower jaw. *Necrolemur* differs from *Tarsius*, moreover, in the more advanced condition of the molars. In the lower jaw the anterior cusp of the trigon, figure 148, has completely disappeared, and in the upper jaw the molars are almost fully quadritubercular. *Microchœrus* in all probability comes in the same group, and when more fully known should furnish a closer approximation to the Indrisinæ than *Necrolemur*, on account of the development of a mesostyle in the upper molars. A further character in which *Necrolemur* resembles the Indrisinæ is the lack of differentiation of the anterior teeth into incisors and canines, as well as their tendency to the procumbent position.

Paleontological Laboratory, Yale University Museum,
New Haven, Conn.

ART. XIX.—*Notes on a New Meteorite from Hendersonville, N. C., and on additional pieces of the Smithville, Tenn., Fall;* by L. C. GLENN.

LAST spring Dr. W. H. Jarman of Nashville added to the Jarman collection in geology here a stony meteorite which had been presented to him by Capt. C. F. Toms of Hendersonville, N. C. The writer immediately wrote to Capt. Toms asking for all the information he could give as to the time, place and circumstances of the fall or find. The following extract from his reply contains all the information obtainable on these points. "About the year 1876, when I was quite a boy, a meteor passed over this town from east to west. My father describes it as being as large as a 'wash pot' and it appeared to break into three pieces near the spot where this piece came from. It was very bright, lighting up the whole country and exploded with a great roar like a cannon. In 1901 Wm. Corn, a citizen living near the place, about three miles northwest of Hendersonville, brought this piece to us and we recognized what it was. He found it in the vicinity of what is known as the county home for the aged and infirm, probably on the land belonging to it."

The meteorite as received weighed 11 pounds and 6 ounces. The original weight, however, had been perhaps two pounds greater than this, as two pieces had been broken off before it reached the writer's hands. From one corner a large piece had been broken off, and from another a small flake had been removed. Concerning these pieces, Capt. Toms says, "The pieces broken off were used to make an assay (which has been lost) and therefore cannot be had."

The shape of the mass received was somewhat cubical, though one face of the quasi cube was considerably modified by an irregular portion projecting above it. The exact shape of this projecting portion cannot now be ascertained, as from it had been removed the larger of the two missing pieces above referred to. When resting on a face that may very conveniently be regarded as the base, it stands $6\frac{1}{4}$ inches high, is $5\frac{7}{8}$ inches wide and $5\frac{1}{2}$ inches thick. Its extreme diagonal length is 8 inches. The edges are all either gently or acutely rounded. A considerable portion of the surface is smooth and nearly flat, while the rest of the surface is covered with irregular, shallow pittings or undulations.

The underlying surface color is almost black, but it is generally obscured by rust-colored areas, due to weathering. On broken surfaces it is seen that weathering has produced a rusty-

colored layer a thirty-second to a sixteenth of an inch thick over most of the surface. While there are no cracks in the mass, yet the interior shows that weathering influences have made themselves felt to some extent at least through probably the entire mass. Freshly broken surfaces show a very dark gray mass with many minute rust-colored specks and numerous small masses of metallic luster and either a gray or a light pyritic yellow color.

A piece weighing one and a half pounds was removed and retained and the rest of the mass was given in exchange to the U. S. National Museum, and Professor G. P. Merrill will doubtless soon publish a description of the mineralogical and other characters of the stone. The fall is new and adds one more to the already considerable list of meteorites known from North Carolina.

Three pieces of meteoric iron from Smithville, Tenn., are mentioned by Huntington* in his description of the find. A fourth piece was sent, so the writer has been informed, to the U. S. National Museum. During the past year two additional pieces have come into the possession of the writer. They were found about forty years ago at Berry Cantrell's, one mile west of Smithville, Tenn. The larger mass weighed 3460 grams and was of compact rounded shape and evidently entire. The smaller weighed 478 grams and had had a portion removed by some one. The character of the masses was similar to that described by Huntington and, although the place where they were found was not just the same as that where the previously reported masses came from, they all belong undoubtedly to the same fall, which may have been scattered over a considerable area. Huntington's suggestion of collusion in these Smithville finds and his regarding them as being really part of the Cocke County iron, do not seem to the writer from his knowledge of the circumstances to be at all well taken. No object can be seen in any one going to the trouble of securing portions of a fall, carrying them several hundred miles across the mountains, secreting them forty or fifty years and then making presents of them to strangers! The only reasonable conclusion is that the Smithville finds fell near Smithville and not in a far distant corner of the state.

* Huntington, O. W., Amer. Acad. Arts and Sci. Proc., vol. xxix, pp. 251-260, 1894.

Vanderbilt University, Jan. 19, 1904.

ART. XX. — *Periodic Migrations between the Asiatic and the American Coasts of the Pacific Ocean;* by JAMES PERRIN SMITH.

THE fossil marine faunas of the western coast of the United States, of British Columbia, Alaska, Japan, and India are fairly well known, especially in the Mesozoic era. These faunas are now similar, now different in the various provinces, or in parts of them, presenting an apparently inextricable confusion not capable of any rational explanation. But this confusion is only apparent, for when studied in succession, a regular scheme can be traced in the relationships and diversities of this ancient region. And the changes that are noted point to changes in physical geography that would be insignificant in themselves, compared with continental uplifts and subsidences, though by no means insignificant in their effects. Also there is abundant independent physical evidence that these changes really took place, so they are in no sense merely hypothetical.

Briefly stated, the facts are these. There is at present a remarkable similarity in the living marine molluscs of the western coast of North America and of the eastern coast of Asia in approximately the same latitudes, and this similarity can be traced back with certainty until the Lower Trias, and probably even below that. But the resemblance is not continuous, there being periods in which the faunas were unlike, and these periods of interruption recur several times, although not regularly. It is clear that no migration is taking place between the opposite sides of the Pacific now, and equally clear that such migration did go on in comparatively recent geologic time, when a large part of the present species of marine invertebrates already existed. It remains to state the facts in succession, and then to show how the intermigration must have taken place, and the cause of the periodic interruptions, reasoning back always from modern conditions to those of the past.

Ancient Faunal Relations.

Paleozoic time.—We know little with certainty of the faunal geography of the Paleozoic of the western coast of America except that during the Carboniferous the connection seems rather to have been with northern Asia than with the interior of North America. The kinship of American and Asiatic forms can not be charged to universality of faunas or physical conditions, for we know that there was nearly as much provincial differentiation in the marine Carboniferous as there is now.

Lower Trias.—The writer* has already shown in several papers that the Lower Trias of California and the Great Basin shows an intimate relationship to that of Asia, and none with that of the Mediterranean region. Many genera are represented by closely allied species on both sides of the Pacific Ocean that are wholly unknown in Europe at that time; such are *Flemingites*, *Ophiceras*, *Proptychites*, *Lecanites*, *Aspidites*, *Clypites*, *Pseudosageceras*, *Ussuria*, and many others. Some of the species of these may even be identical, but even without this the association of the genera is such that a paleontologist from Asia would feel himself to be perfectly at home while collecting in eastern California or in Idaho. In some respects the relationship of the fauna of the western coast seems to be closer with that of northern Asia than with that of India; for instance, *Pseudosageceras* and *Ussuria*, which are not uncommon in the Meekoceras beds of the Inyo Range in California, and the Aspen Mountains of Idaho, have never been found anywhere else except at Ussuri Bay in eastern Siberia, from which place they were first described. These genera are probably not of American origin, and most of them are of unknown antecedents. But, fortunately, the geologic history of some of these forms is known. *Ophiceras*, *Xenaspis*, *Xenodiscus*, and *Hungarites*, which occur in the Trias of Asia and America, chiefly in the lower beds, have also been found in the Permian of southern Asia. To this region, then, we must look for the source of the Lower Triassic ammonites which appear as immigrants in the American waters, marking the first distinct Asiatic invasion.

After the deposition of the Meekoceras beds, a few species with Mediterranean affinities begin to make their appearance in western America. But it is noteworthy that, at this time, the Indian still appears to have been cut off from the Mediterranean region.* The geographic regions described by E. von Mojsisovics† for the Trias will hold good only for the Lower Trias, and probably not even for the whole of that period.

Middle Trias.—In the Middle Trias a certain kinship still persists between the marine faunas of western America and Asia, though this may be due as much to inheritance from similar ancestors, as to immigration. No species are any longer common to the two regions, and many genera, even, are different on opposite sides of the ocean. But at the same time a kinship between the American and the Mediterranean faunas begins to be noticeable, especially in the nodose ceratites and other members of the Ceratitidæ. It is possible that during

* Jour. Geol., vi, 776–786, 1898; Jour. Geol., ix, 512–521, 1901.

† Arktische Trias-Faunen, pp. 147–155, 1886, and Beitr. Kennt. obertriadischen Cephalopoden-Faunen des Himalaya, pp. 114–128, 1896.

the Middle Trias a connection was established between these regions through some other way than the Indian branch of the old central Mediterranean, or "Tethys," but we have no way of knowing this passage. It seems possible, however, that it may have been through the Boreal region. The writer* has already given a suggestion of the faunal change at the end of the Lower Trias, based on his own collections made in Nevada during the summer of 1902. No species are thought to have been absolutely identical with European forms, but many are so similar to species long known from the Alps that some sort of connection is beyond question.

Upper Trias, Subbullatus beds.—The writer† has brought out several years ago the relationship of the Trias of California to that of the Alps. Further study, in field and museum, has served only to strengthen this hypothesis, and recent work in India has given a means of comparison with that region, showing that the same thing is true there also.

The Karnic horizon, zone of *Tropites subbullatus*, contains many elements common to the Mediterranean region and western America, and many of these are also found in India. *Tropites subbullatus*, *T. torquillus*, *Paratropites Sellai*, *Entomoceras sandlingense*, *Sagenites Herbichi*, *Polycyclus Henseli*, and *Halobia superba* are common in both California and the Tyrolean Alps, and many other species are very closely related. Most of these are represented in India by forms that may be identical with them, although complete publication of recent geologic explorations in India must be awaited before a final decision can be made.

Now it is well known that the Tropitidæ appeared as immigrants in the Mediterranean and the western American regions in the Upper Trias, without local ancestors. They also appeared at the same time in India, but since we do not yet know the faunas of the upper part of the Middle Trias in that region, there is still a possibility that the Orient may have been the source of this part of the fauna, for it is highly probable that the Indian province was the connection between Europe and America. This Karnic fauna, however, is not yet known elsewhere in Asia, and the only proof we have of the migration is the occurrence of similar species in the widely separated regions. The path of this migration cannot be traced, for fossils of the zone of *Tropites subbullatus* are known in America only in California, not having been found at any other place in either North or South America.

Upper Trias, Noric horizon.—Fossils of the Noric horizon,

* Centralblatt für Mineral. Geol. und Pal., pp. 689–695, 1902.

† The Metamorphic Series of Shasta County, California, Jour. Geol., ii, 588–612, 1894.

zone of *Pseudomonotis ochotica*, are known in Alaska, British Columbia, California, Nevada, and as far south as the coast of Peru. *Pseudomonotis ochotica* is widely distributed in Siberia and Japan, and is probably identical with the American *Pseudomonotis subcircularis*. This group is distinctly Asiatic in origin, and never reached the Mediterranean waters. Its appearance in America marks another Asiatic immigration, but this time it came from the north. We see here a reversion to the conditions of the Lower Trias, but on the Asiatic side the immigrants do not seem to have reached any further than to Japan. The widespread occurrence of beds with *Pseudomonotis ochotica* around the northern shores of the Pacific and around the Arctic Ocean shows a transgression of the sea on what was formerly a continental border. These forms were endemic in the Boreal region, and made their way southward when the transgression of the sea opened the way, on both sides of the Pacific. Of course, this may not have had anything to do with climate, but at the close of the Karnic epoch the fauna of western America shows a sudden change of facies from the Indian-Mediterranean character to that of Siberia, which shows, at least a change in connections. A passage from the Arctic to the Pacific was reopened between Asia and America, and the Boreal, though not necessarily cold-water, type came through, making its way southward.

Deep water, cutting off Asia from America, would have separated the two Triassic regions just as effectively as cold water, but since there was free passage for the group of *Pseudomonotis ochotica* down both sides of the Pacific, it is strange that it did not reach Tropical India, and that the Tropical Indian forms ceased temporarily to come to America. If such changes had occurred in Tertiary time we would say without hesitation that the Boreal invasion marked an influx of cold water from the Arctic Ocean through the open passage between Asia and America.

The group of *Pseudomonotis ochotica* has also been cited by Suess* from New Caledonia, but this occurrence is doubtful, since Rothpletz† found only *Monatis salinaria*, a Mediterranean type, in that region. It may be, however, that in the Indian Ocean the Boreal and the Mediterranean facies were temporarily united, in which case the presence of *Pseudomonotis ochotica* would not necessarily be a proof of the southward extension of a lower temperature.

A modern instance of the same restricted dispersion is seen in the occurrence of *Purpura lapillus* in the North Pacific.

* La Face de la Terre, ii, 422.

† Perm-, Trias- und Jura-Formation auf Timor und Rotti im indischen Archipel, p. 90.

This species is abundant in the North Atlantic, and has made its way through the Boreal region into the Pacific. On the western coast of North America, where there are no sudden changes in the temperature of the sea water, this species has made its way as far south as Margarita Bay, in lat. 24° N., mean temperature 73° F. On the Asiatic side it has made its way through Bering Sea down the shores of Kamschatka with the cold water, but has been stopped by the sudden change of temperature at Hakodadi, lat. 41° N., Japan, mean temperature 52° F., where the warm Japan current meets the cold current from Bering Sea. That this is not an accident of distribution is shown by the fact that *Purpura lapillus* has, in the Atlantic, a similar distribution, and for the same reasons. On the African side it reaches lat. 32° N., mean temperature 66° F., and on the American side it is barred back by the sudden change of temperature at lat. 42° N., mean temperature 52° F.* There can be no doubt that the temperature, or rather evenness of change of temperature, controls the distribution of *Purpura lapillus* now, and it would seem only reasonable to suppose that similar conditions in the Trias caused the unequal distribution of *Pseudomonotis ochotica.*

Lias.—It is probable that during the Lias the southward migration of the Boreal type of animals was interrupted, for the *Arietites* group, which was characteristic of that epoch in Europe, is known in California and Nevada, as well as in Mexico and South America. It was, however, practically universal, having been found also in the Indian region, though not as yet from the Jurassic Arctic sea. In the Upper Lias the genus *Amaltheus* was widely distributed in Europe and in the Boreal region, but has not yet been found in North America. It is known from New Grenada, associated with a typical Mediterranean fauna. It seems probable that the Lias of California and Nevada is merely a northward extension of the South American type.

Middle Jura.—In California the Middle Jura, like the Lias, appears to have been of Mediterranean type, but in the Black Hills we have a southward extension of a fauna characteristic of northern Europe, and of the region around the northern Pacific Ocean. This boreal type is extensively developed in Alaska and in northern Siberia, and its appearance in the Black Hills marks the beginning of another incursion from the north.

Upper Jura.—The incursion of the Boreal fauna into America which began in the Middle Jura reached further southward and westward in the Mariposa epoch of the Upper Jura, down through California to San Luis Potosi in Mexico.

* A. H. Cooke, Cambridge Natural History, iii, p. 363, 1895.

This fauna is characterized by the genera *Cardioceras* and *Aucella*, which had their home in northern Europe and northern Siberia, and appeared in western Europe only sporadically as the result of incursions. Pompeckj* has shown in several papers that a Polar sea existed in the Middle and Upper Jura and Lower Cretaceous, from which incursions were made from time to time into the more southerly regions, when changes in physical geography made it possible. He has also shown that the *Aucella* fauna had its real home in that region, where it formed a truly genetic series, and that it appeared only sporadically in other regions, where the species speedily degenerated and the fauna becomes extinct unless replenished by another migration.

The suggestion of climatic influence on the dispersion of marine animals in the Upper Jurassic is very strong, for the *Aucella* did not make its way into the Indian Ocean, although the way was probably open. It went only where the conditions of its own proper habitat existed, if only temporarily. Even so conservative a naturalist as J. D. Dana† admits that in Jurassic time there was a cold current to the southeast along the western coast of North America, making possible the migration of *Aucella* from the Boreal into warm temperature or even subtropical waters.

Aucella did, however, make its way into northern India, probably from southern Russia, during a time of extension of the sea in that direction in the Kimmeridge and Tithonian epochs.‡

Lower Cretaceous.—After the Jurassic beds were laid down there was in California a break in sedimentation, and the uplift of the Sierra Nevada took place. But it was orogenic, and although widespread, it did not affect the geographic relations, for with the opening of the Cretaceous the same northern types were still there. *Aucella* was still the most characteristic genus, and along with it were many species of ammonites closely related to Russian species. *Aucella crassicollis* was even identical with a characteristic Russian form. These Knoxville species were probably in part immigrants from the Boreal region, although some of them may have been modified descendants from species that were endemic in the American

* Ueber Aucellen etc. N. J. für Min. Geol. und Pal. xiv, 343, 1901 and Jura Fossilien aus Alaska, Verh. k. o. Russ. Min. Gesell. (St. Petersburg), xxxviii, 376, 1901. The Jurassic Fauna of Cape Flora, Franz Josef Land; The Norwegian North Polar Expedition 1893–1896, Scientific Results, p. 141, 1898.

† Manual of Geology, p. 794, 1895.

‡ S. Nikitin, Bemerkungen über die Jura-Ablagerungen des Himalayas und Mittelasiens. Neues Jahrb. für Min., Geol. und Pal., ii, 124, 1889.

waters. Before the end of the Knoxville epoch, while the Boreal forms still persisted, *Lytoceras* and *Phylloceras*, genera that were never found in northern Europe and Asia, appeared in the Cretaceous beds of the western coast of America. These forms seem to have been endemic in the warm regions of southern Europe and Asia, and their appearance marks a resumption of interchange between India and America, around the shore-line formed by closing the gap between Asia and Alaska. In proof that the gap was really closed, it may be said that the flora of the Knoxville beds and of the equivalent Kootanie formation appears to indicate a warm temperate climate,* which would mean that the cold current from the Arctic Ocean had been cut off by a rise of the land.

During the Lower Cretaceous *Aucella* made its way into the Tropics, around the Pacific Ocean, so that its later occurrence gives no evidence of southward extension of Boreal climatic conditions.†

Upper Cretaceous.—With the opening of the Horsetown epoch all reminiscences of the Boreal fauna are gone, and the Tropical character of the inhabitants of the sea on the western coast of America is marked. A close affinity and even identity of species with the Indian fauna characterizes this epoch. And it is noteworthy that the Puget Sound Horsetown and Chico faunas are even more closely allied to those of India than are those of California. Migration appears to have been free between Asia and America, but the species did not all range so far south as California, thus indicating the direction from which they came. Of course, not all the marine forms on the west coast of North America came from Asia, but the Asiatic portion is the only one that we can trace to its source.

The following species that occur in the Horsetown and Lower Chico of western America are regarded by Kossmat‡ as identical with species in southern India:

Lytoceras Kayei Forbes.
L. —— *timotheanum* Mayor.
L. —— *cala* Forbes.
L. —— *indra* Forbes.
Hamites glaber Whiteaves.
Schloenbachia inflata Sowerby.
Acanthoceras Turneri White.
Pachydiscus otacodensis Stoliczka.
P. —— *arialurensis* Stoliczka.
Desmoceras diphylloides Forbes.

* T. W. Stanton, Jour. Geol., v, 599, 1897.

† Pompeckj, Ueber Aucellen und Aucellen-ähnliche Formen, Neues Jahrb. für Min. etc., xiv, 348, 1901.

‡ Beitr. Pal. und Geol. Oesterreich-Ungarns und des Orients, ix, Parts 3 and 4, 1895.

Desmoceras latidorsatum Michelin.
Puzosia planulata Sowerby.
Hauericeras Gardeni Bailey.
Phylloceras Whiteavesi Kossmat.
P. —— *Velledae* Michelin (cited as the probable equivalent of *P. ramosum* Meek).

Besides the above, F. M. Anderson* describes the following species from the lower Chico beds as identical with Indian forms: *Schloenbachia propinqua* Stoliczka, *S. blanfordiana* Stoliczka, *Desmoceras sugata* Forbes. Nearly all these species that are common to the western coast of America and India also occur in Japan, and many of them also in eastern Africa. They are, then, tropical or subtropical in habitat. Whether the appearance of the *Aucella* fauna of the Upper Jura and the Lower Cretaceous in the North Pacific meant cold water or not, the appearance of the Indian forms in the same region can only be interpreted to mean that a warm temperature prevailed there at that time, and that conditions were equable around the old shore line from India as far as California.

With the closing of the passage between Asia and America, the warm Japan current, which is now chilled by the cold southwesterly current from Bering Sea, would warm up the whole coast line and make the waters of western America warmer than they are now. We also have evidence that the temperature of the land in the northern hemisphere was warmer than at present, for Heer† has shown that the Cretaceous floras of Greenland, Spitzbergen and Alaska contained cycads and other forms indicating a mean temperature of about 70° F.

Upper Chico.—In the upper Chico horizon (Senonian), of California and Oregon the connection with India appears to cease, and a path of migration from the interior Cretaceous sea of America seems to have been opened.‡ Several species of pelecypods are identical with species from the upper Missouri province, and some of the ammonites are closely allied.

Eocene.—During the early Tertiary, or Tejon epoch, in California we have no evidence of any migration from Asia, but it is plain that a connection existed with the Eocene sea of the Atlantic region. *Venericardia planicosta*, which is abundant in the Claiborne beds of the states around the Gulf of Mexico, has been found at a number of places in Oregon and California, and it appears to be more common in southern California than anywhere else on the western coast. Other

* Cretaceous Deposits of the Pacific Coast, Proc. Calif. Acad. Sci., iii, Ser. Geol., vol. ii. No. 1, 1902.

† Flora Fossilis Arctica, vi and vii, 1882–83.

‡ F. M. Anderson, Cretaceous Deposits of the Pacific Coast, p. 59, 1902.

species of this fauna may be identical with Atlantic forms, at any rate some are closely related, and it is probable that the passage lay to the south of California.

Miocene.—In the middle Tertiary the passage to the Atlantic seems to have been closed, and there is no evidence that communication was resumed with Asia. The Miocene fauna of California seems to have been largely endemic, for no Atlantic species are found in it, and the only possible admixture consists of forms from the south, and of circumboreal species that made their way down from the north. But towards the end of Miocene time the land appears to have risen in the north, cutting off the Arctic Ocean from the Pacific, and allowing land plants to migrate from Asia to North America. Asa Gray* has shown that in the Miocene northeastern Asia and northwestern America were connected, that over those regions there existed a flora like that of warm temperate latitudes at the present time, and that this connection persisted almost to the beginning of the Glacial epoch.

We have no evidence that a migration of marine invertebrates from Asia began as early as the upper Miocene, but they would naturally be slower in their movements than land plants, and consequently would lag behind them. The Tertiary uplift of land in the northern hemisphere may be correlated with the widespread orogenic uplift of the Coast Ranges on the Pacific side of North America, which in California and Oregon is known to have come at the end of the Miocene, and before the Pliocene beds were laid down.

Pliocene.—There is good geologic evidence that the land-bridge between Asia and America still existed in the Pliocene, for there seems to have been a constant interchange of vertebrates in that quarter,† in the Miocene, Pliocene, and early Pleistocene. Also students of other groups find it necessary to postulate such a connection to explain the migration of animals. A. E. Ortmann‡ says that the identity of some of the fresh-water crustaceans in Siberia and Alaska proves a recent connection of those parts, and that this union of the continents began in the middle of the Cretaceous and lasted into the lower Pleistocene. G. M. Dawson§ is of the opinion that in the Pliocene the Pacific coast of North America stood about 900 feet higher than now, which would be ample to connect the two continents, and cut off the cold water from the North Pacific. And we still have evidence of this former elevation of the Alaskan region, for in the Aleutian Islands,

* Amer. Jour. Sci. (3), cxvi, 195, 1878.
† H. F. Osborn, Science, xi, 571, 1900.
‡ Proc. Amer. Phil. Soc., xli, 291, 299 and 316, 1902.
§ Quoted in Dana's Manual of Geology, 949, 1895.

commonly regarded as a chain of new volcanoes, granite appears in several places.*

At this time the marine faunas of Japan and the western coast of America begin to be remarkably similar, with many species identical, which can only mean that intermigration had set up along the shore line. And the identical species are not merely circumboreal, for many of them have never been found in the Boreal region. A list of these, and their geologic range, will be found on the table on page 229.

The rise of the land in the northern hemisphere, as shown by the distribution of land and fresh-water animals, would cut off the southward cold current from the Arctic Sea, and prevent the chilling of the Japan current south of Bering Sea. The Japan current would then warm the shores of Alaska, and produce a mild temperature along the old shore line from Japan to California. That it did so is shown by the similarity of the Pliocene faunas of the two now separated regions. At first there was naturally a mixture of Boreal and Japanese forms, for D. Brauns† has shown that the Pliocene of Japan is related to the "Crag" of England; and the upper Pliocene of California appears to indicate a temperature of the sea-water somewhat lower than at present. At any rate, it is clear that the climate around the North Pacific in Pliocene time was merely temperate; this is shown by the fact that while we have an immigration of Japanese species, no Indian forms came with them, as they did in the Upper Cretaceous, when the climate appears to have been subtropical.

Pleistocene and Recent Faunal Relations.

San Pedro epoch.—With the beginning of the Pleistocene the same conditions existed as in the upper Pliocene. Japanese species still abound in the marine fauna, and the character is still somewhat boreal,‡ which may be due to a survival of forms that came in during the colder Pliocene epoch. The land connection with Asia still existed, and free exchange of land animals between Asia and America still went on.

As the waters of the Californian coast gradually became warmer, Mexican species began to creep northward, and in the upper San Pedro fauna we find a number of species that now live only in the Tropics, and have become extinct on the Californian coast.§ This does not mean that connection with Japan

* J. E. Spurr, U. S. Geol. Survey, 20th Ann. Rept., Part vii, 234, 1900.

† Geology of the Environs of Tokio, Mem. Science Dept., Univ. of Tokio, No. 4, pp. 1-82, 1881.

‡ Delos and Ralph Arnold, The Marine Pliocene and Pleistocene Stratigraphy of the coast of Southern California, Jour. Geol., vol. x, No. 2, pp. 117-138 (1902).

§ Ralph Arnold, Mem. Calif. Acad. Science, iii, 29 et seq., 1903.

was cut off, but that the continuation of the conditions that allowed Japanese species to migrate to California finally allowed marine animals to make their way up the coast also.

Glacialists postulate an elevation of the land in the northern hemisphere, in the period preceding and during the Glacial epoch; this undoubtedly cut off the migration of land animals and plants between Asia and America. When this affected intercommunication along the shore-line we do not know, but after the close of the San Pedro epoch the Asiatic immigration ceased, and also the subtropical elements of the marine fauna of California became extinct. With the subsidence following the Glacial epoch conditions returned to the normal, and intermigration with Japan was not resumed. It was too cold for the perpetuation of the warm-water species from the south, though not too cold for the Japanese species to live on in the Californian waters. But the Asiatic colonists in America were not replenished by immigration from the mother country, and those that are found in the Californian province are merely survivors.

Relations of the living faunas of the west coast to that of Japan.—The table on page 229 shows the living species that are common to the western coast of North America and the Japanese province. The number of species is very large, especially when we consider the fact that they are in different zoölogic regions, and separated by more than five thousand miles. Migration of shore forms can not possibly be going on now, for while the distance is no bar to them, the deep water at the end of the Aleutian chain of islands would effectually check all passage in either direction. And the sudden changes in temperature through which marine animals would have to pass are an equally effectual barrier. We have seen already how even a circumboreal species, as *Purpura lapillus*, is checked in its southward passage where the cold current from Bering Sea meets the warm Japan current. Such changes are even more impassable to warm-water species.

In the present similarity of the marine faunas of Japan and the western coast of America we have an example of provinces that were recently connected, but which are now separated by deep water and by differences of temperature in between, while the conditions still remain similar in the two provinces. This separation, however, has existed long enough for some of the species to have become differentiated by evolution, for some to have become extinct in one province while still living in the other, and for the total faunas to have become much changed by immigration from other regions.

At first sight it would seem that the intermigration of the marine faunas has been more recent than the exchange of the

land animals and plants between Asia and America. And indeed this may be so, for a subsidence that would cut off effectually all land organisms might not interfere with the migration of marine animals living at moderate depths. For instance, *Haliotis*, a distinctly Asiatic type, is not known on the west coast of America before the upper San Pedro epoch, and has now made its way southward below California. On the other hand, we must remember the conservative character of marine faunas. Where in the land Pleistocene faunas most of the species have been replaced by others, of the marine Pleistocene animals only a very small percentage has become extinct. We must also note that, of the species now common to the two sides, a large proportion is known to have existed in Tertiary time, and probably nearly all in Pleistocene. In the time that has elapsed since the two provinces were separated, *Lucina acutilineata*, which abounded during the Pliocene in both Japan and California and is still living in Puget Sound, has become extinct in Japan. *Mya arenaria*, also abundant in the Pliocene in both provinces, has become extinct in California, while it still persists in Japan. It has, however been introduced artificially late in the nineteenth century and now abounds in most of the bays on the west coast. On the Alaskan coast *Mya arenaria* did not become extinct, though it did not make its way down to California. It is also probable that *Pecten caurinus* on the west coast and *P. jessoensis* in Japan have become differentiated from their common ancestors.

All this points to a rather ancient separation, not later than the upper San Pedro epoch, at which time the warm-water fauna came up from the south, and never reached Japan.

Summary.

Present physiography.—The living faunas of the Japanese province and of the western coast of North America are rather closely allied, with a large number of species in common, and they live under approximately the same conditions, although they are in widely separated regions. Between them lies a stretch of shore-line running up to lat. 60° N., around the southern shores of Alaska and the Aleutian Islands, but interrupted by the deep channel east of Kamchatka. Also there is a great difference of temperature between them. The warm Japan current, with an average maximum temperature of 86° F., flows past Japan, swings to the northeast, south of the Aleutian chain towards America, and parts off Puget Sound, one branch flowing northwestward along the Alaskan coast, and the main branch southeastward down towards California.

TABLE SHOWING LIVING SPECIES COMMON TO THE WEST COAST AND JAPAN.

	Japanese Province.			West American Province.		
	Plio-cene.	Pleis-tocene.	Living.	Plio-cene.	Pleis-tocene.	Living.
Barbatia gradata Sowerby			×			×
Cardium blandum Gould			×	×	×	×
Cardium corbis Martyn	×		×		×	×
Chlamydochiton annulatus Pallas			×			×
Crepidula grandis Midd.			×	×		
Cryptochiton Stelleri Midd.			×			×
Diplodonta orbella Gould	×		×		×	×
Dentalium hexagonum Sowerby	×		×	×	×	×
Haliotis Kamtschatkana Jonas	×		×			×
Laqueus californicus Koch			×	×	×	×
Lasæa rubra Montagu	×		×		×	×
Leptothyra Carpenteri Pillsbry			×			×
Lima orientalis Adams	×		×			×
Littorina sitkana Philippi			×			×
Lucina borealis Linné	×			×	×	×
Macoma edulis Nuttall						
Macoma inquinata Gould			×			×
Macoma nasuta Conrad	×		×	×	×	×
Macoma secta Conrad			×	×	×	×
Modiola flabellata Gould	×			×		
Macron Kelletii A. Adams			×			×
Mopalia muscosa Gould			×			×
Murex foliatus Gmelin			×		×	×
Mya arenaria Linné	×		×	×		
Mytilus edulis Linné	×		×		×	×
Nucula Cobboldiae Sowerby	×		×			
Natica clausa Broderip			×		×	
Panopæa generosa Gould	×		×	×	×	×
Pecten caurinus Gould	?		?	×	×	×
Pecten jessoensis Stimson	×		×			
Pecten hericeus Gould			×	×	×	×
Pecten islandicus Müller			×	×	×	×
Placunanomia macroschisma Deshayes			×	×	×	×
Purpura crispata Chemnitz			×	×	×	×
Purpura lapillus Linné	×		×	×		×
Sanguinolaria Nuttalli Conrad			×			×
Saxidomus Nuttalli Conrad			?	×	×	×
Siphonalia Kelleti Hinds			×		×	×
Siliqua patula Dixon			×			×
Solen sicarius Gould			×	×	×	×
Tapes staminea Conrad			×	×	×	×
Tellina bodegensis Hinds			×	×	×	×
Terebratulina caput-serpentis Linné	×		×			×
Tresus Nuttalli Conrad	×		×	×	×	×
Tritonium oregonense Redfield			×		×	×
Trophon orpheus Gould			×	×	×	×
Velutina laevigata Pennant			×		×	×
Venus Kennerlyi Carpenter			×			×

But in lat. 42° N., off Hakodadi, Japan, it is met by the cold current from Bering Sea along the coast of Kamchatka, and from there on the current is merely temperate, being reduced

to about 66° F. It tempers the Alaskan waters, but makes the waters along the shores of California colder than they should be, as compared with similar latitudes elsewhere. These currents have been fully described by Professor George Davidson,* who has made many hydrographic investigations in that region; and by Dr. W. H. Dall,† who verified much of the work of Professor Davidson, but showed that there was no northward branch of the Japan current extending up into Bering Sea.

At present the migration of shallow water species is stopped by the depth of the channel at the end of the Aleutian chain, and also by the cold water that extends southwestward from Bering Sea. But a rise of 200 meters would close Bering Strait, and about one-half of Bering Sea, giving a shore-line coinciding approximately with a great circle. It would then leave the Aleutian chain as a long narrow peninsula reaching out from Alaska towards Siberia, separated from Kamchatka by a rather narrow but deep channel; while the mainland of Alaska and Siberia would be united by a broad land-bridge. This change in the height of the land would cut off all influx of cold water from the Arctic Sea, and the Japan current, not being chilled by cold water from Bering Sea, would still be warm along the Aleutian Islands and the Alaskan coast, and no doubt the tempering effect would be felt even as far south as California. A rise of 2,000 meters would not connect the Aleutian chain with Kamchatka, but at least would give a stretch of shoal water along which migration would be easy for shore forms. In any case there would be a shore line with temperate or warm water all the way from Japan to California.

While it is not likely that the land in the northern part of the Pacific has, in recent geologic times, stood 2,000 meters higher than now, it has certainly stood several hundred feet higher, and whether much or little, we know from the migrations of land plants and animals between Asia and America that there has been a land-bridge. Now in any case, whether in the present or in the past, similar contemporaneous faunas mean similar conditions, and identical species mean immigration from one region to the other, or from a third region to both. In the case of Japan and the west coast of America the only outside region that can have furnished elements to both is the Boreal region, and circumboreal species in both provinces are well known. But a large majority of the species now common to both provinces are not circumboreal. Thus intermigration is the only satisfactory explanation of the pre-

* Report Supt. U. S. Geodetic Survey, 1867, Appendix No. 18, p. 202, 1869.

† Rept. Supt. U. S. Coast and Geod. Survey for 1880, Appendix No. 16, p. 322.

sent distribution of most of the species that are common to Japan and California.

Unlike species living contemporaneously in similar conditions can only mean separation by physical barriers; these to the marine shore-animals are: a land-mass; deep water; or great difference of temperature in between. The two latter are the only barriers that can ever have been interposed between Japan and the west coast of America, and a rise of 200 meters would remove both.

The hypothesis of former migration around the Alaskan-Aleutian shore-line explains satisfactorily the close relationship between the living marine animals of Japan and California, while the present interruption and the length of time during which it has persisted explain the unlikeness of the greater part of the two faunas. A periodic recurrence of this interruption accounts for the periodically recurring unlikeness of faunas of these two provinces in the past, and also for the fact that the successive faunas of California do not form a genetic series, but rather one showing periodically diverse origin and characters. With this in mind we can find out where the successive migrations came from, and why the present fauna shows such a commingling of forms derived partly from Asia and partly from the more southerly regions of America.

Past physiography.—The old idea of uniformity of climate all over the earth before the Tertiary period still remains as an undercurrent in the minds of geologists, and stands in the way of any theory that accepts the influence of differences of temperature in causing faunal differences in the past. Stanton* denies that the change of character of the Cretaceous fauna of the west coast at the end of the Knoxville epoch, from the Boreal to the Indian type, can be attributed to change in climate. Others have criticized Neumayr's† theory of climatic zones in Jurassic and Cretaceous times, and there can be no doubt that Neumayr carried his theories entirely too far, reconstructing ancient physical geography on very little evidence. But the fact that Neumayr was mistaken in many things is no argument that the principle was wrong. No doubt geographic connections and presence or absence of opportunities for free intercommunication were of just as great importance as differences of temperature in governing the distribution of faunas in the past, as well as now. But it will not do to leave climate entirely out of the reckoning.

The assumption of a uniform temperature over the earth before the Tertiary period rests on an insecure basis. If any

* Jour. Geol., v, 598, 1897.

† Klimatische-Zonen während der Jura- und Kreidezeit. Denkschr. k. Akad. Wiss. Wien, xlvii, 1883.

former climate was uniform, it must have been warm, and the temperature must have been warmer the further we go back in geologic history. And yet we have evidence that the temperature was not uniform even in the Paleozoic. It is well known that over parts of India, Australia and South Africa there is good evidence that there was a Permian glacial epoch, while we know from abundant contemporary floras in other parts of the earth that this glaciation was not universal. In South America in the same latitudes as the glaciated region of the Orient there does not appear to have been a cold period. In this, then, we have proof that there was great diversity of climate even in the Paleozoic era.

Now it would be absurd to account for the difference between the cold-water faunas of California in the Pliocene and lower San Pedro formations and the warm-water fauna of the upper San Pedro, and the contrast between the latter and the present cooler water fauna of the California coast, on any other hypothesis than differences of temperature. For all this is based on species that are still living, where we know the exact conditions of geographic connection and temperature under which they live, and by which their distribution is governed. These differences of temperature are slight, and the changes in physical geography that caused them are insignificant, though far-reaching in their effects. All this, of course, applies only to the shore lines affected by the marine currents, and does not necessarily have anything to do with continental climates.

It would seem equally rational to explain similar distribution in the past by the same hypothesis. The faunal relations between western America and eastern Asia from the Trias to the present were the same, Asiatic facies alternating with periodically recurring invasions of the Boreal type. If differences of temperature can account for the connections and separations of the living faunas, they must be taken into account in explaining similar connections and separations in Tertiary, Cretaceous, and even Jurassic and Triassic times.

On homotaxis.—The similarity of the fossil faunas of the Orient to those of the west coast of America is, indeed, surprising, but not more so than that of the living faunas of Japan and the Californian province. It is important in the correlation of these deposits to determine whether they are really synchronous. Ever since Huxley* cast doubt upon the simultaneous occurrence of the same faunas in widely separated regions, geologists have been inclined to assume that this similarity is good proof that they were not really synchronous. But we know that the present faunas of Japan and the Cali-

* Quart. Jour. Geol. Soc., London, xviii, 40–54, 1862.

fornian province are synchronous and similar, with many identical species, although they are in different geographic regions. And there is no more reason to assume that the similar Mesozoic faunas of the two regions were not synchronous than there is for the present time. The modern instance shows that they may just as well have been synchronous as not.

Biologists are often sceptical as to identity of species in separated regions in the past, on the ground that the criteria for determining fossils are not so exact as those applied to recent forms. But this is also fallacious, since the recent shells of Japan and California have been subjected to most careful examination by critical conchologists, and many species found to be identical. There is, therefore, no presumption against the identity of similar species in the two regions of Cretaceous, Jurassic, or even Triassic age.

On the permanence of the shore-line.—The marine sediments and their fossils around the North Pacific, from the Trias on to the present time, show that the shore-line has been, during all that time, approximately as it is now. There is no reason to theorize about great changes in physical geography, when such a simple matter as the periodic opening and closing of Bering Strait by rising and sinking of the land in that quarter will account satisfactorily for all the changes in character and distribution of the marine faunas. E. Haug,* in his studies of the distribution of Mesozoic formations and organisms, has invented the theory that during Mesozoic time a great continent existed where the Pacific Ocean now is. Whatever may be true of the rest of that ocean, there is no necessity for supposing a continent to have existed formerly in the North Pacific, when all the facts may be explained more easily on the hypothesis of the permanence of the shore-line approximately as it is now. This has nothing to do with the general proposition of the permanence of continental plateaus and oceanic basins, but merely proves a particular case, and suggests that some of the ancient oceans, that are to be found on maps purporting to represent the former continents and seas, may be only epicontinental seas.

* Les Geosynclinaux et les Airies continentales. Bull. Soc. Géol., France (3), xxviii, 646.

Stanford University, California.

ART. XXI.—*Triticites,* a New Genus of Carboniferous Foraminifers*;† by GEORGE H. GIRTY.

WHEN, in the course of preparing a report on the Permian fauna of the Guadalupe Mountains, I came to study the species described by Shumard as *Fusulina elongata*,‡ my attention was engaged by a structural difference of some mark between it and the form from the Coal Measures strata of the Mississippi Valley, commonly identified as *Fusulina cylindrica*. I was consequently led to consider the structure of typical *Fusulina*, and found that the Guadalupian species, and not the common Pennsylvanian one, agrees with the Russian form. The discriminating character which is shown by Fischer-de-Waldheim's original figures of *Fusulina*, by specimens from Russia, and by most figures and descriptions in manuals,§ etc., resides in the partitions which separate adjacent chambers in the same concentric series.

As is well known, each chamber is formed by a narrow prolongation of the outer wall in the direction of revolution, followed by a sharp deflection toward the axis to meet the volution below. The partition thus formed is not, however, complete, minute apertures being left along its lower margin.‖ In true *Fusulina* this partition wall is strongly and regularly fluted in a radial direction, and the arrangement is such that the concave flexures of one partition are opposite the convex flexures of the next, the approaching curves coming in contact more or less precisely along a line. Thus what would otherwise have been a single long chamber extending unobstructed from end to end, is divided into a large number of chamberlets. These are usually quite regular and have the shape of prisms with subrhombic section. The regular fluting of the partitions is often well shown by the aperture, but no intimation of it is conveyed by the straight depressed sutures which prominently mark the external surface. Apparently the fluted structure is not introduced until just after the wall has assumed a radial direction, when it is concealed by the overlap of the succeed-

* From *triticum*, a grain of wheat.

† Published by permission of the Director of the U. S. Geological Survey.

‡ St. Louis Acad. Sci., Trans., vol. i, 1859, p. 388.

§ As, for instance, on p. 31 of Steinmann and Döderlein's Elemente der Paläontologie (Leipzig, 1890), on p. 104 of Zittel's Handbuch der Paläontologie, Bd. I (Munich and Leipzig, 1876–1880), on p. 32 of Zittel's Textbook of Palæontology (London and New York, 1896), on p. 136 of Nicholson and Lydekker's Manual of Palæontology, vol. i (Edinburgh and London, 1889), etc. See, also, Geology of Russia, etc., by Murchison, de Verneuil, and Keyserling, vol. ii, 1845, pl. i, fig. 1*e*.

‖ Indicated by the frequent failure of the partition walls to extend to the preceding volution.

ing wall. Let, however, the outer wall be removed by weathering or by artificial means, and the surface is seen to be very regularly divided into rhombs, which the eye naturally follows in spiral rows.

In the form from the Mississippi Valley for which the name *Triticites* is proposed, the partitions are for the most part straight, and not fluted except in the immediate vicinity of the axis, so that the greater portion of each chamber is not divided into chamberlets. There is also a slight formal difference between *Triticites* and *Fusulina*, since the former seems not to occur in the elongate subcylindrical shapes often found in the latter. *Triticites* is usually subglobose or spindle-shaped, but as *Fusulina* likewise develops these forms, configuration is of but limited importance in discriminating the two genera.

1

Transverse section.
×10.

2

Longitudinal section.
×10.

Externally they will many times look almost precisely alike, except for the aperture, which, if exposed, will at once serve to distinguish them. In weathered specimens the long almost parallel lines of the partitions in *Triticites* are in marked contrast to the reticulation formed by these structures in *Fusulina*. Transverse sections in the two genera are sometimes nearly alike. In each case a spiral wall is seen from which in *Triticites* simple projections extend at regular intervals toward the center, reaching in some cases nearly, and in others completely, to the preceding volution. This is well shown by fig. 1, which represents *Triticites secalicus*. A transverse section through *Fusulina* presents a similar appearance, save that the partition walls are frequently represented by looped or forked lines, instead of by simple ones. The radial walls are seen in many cases to be incomplete, and it is probably by means of the apertures thus left that communication between succeeding chambers was maintained. In longitudinal section the difference is more apparent. The concentric walls of *Fusulina* enclose between them lines, sometimes straight, sometimes curved, often loop-shaped, which are the edges of the inter-

sected fluted partitions, the direction of which is seldom the same as that of the section. In longitudinal sections of *Triticites* there extends along the axial line a band of anastomosing walls, sometimes constituting a more or less regular network, but usually disordered and confused. Aside from this the space between the concentric walls over the median and larger portion of the volutions is uninterrupted, except as some irregularity permits the section to cut one of the longitudinal partitions. Fig. 2 represents a longitudinal section through *Triticites secalicus*. The undivided chambers are well shown in this section, and the wrinkled partitions near the ends of each chamber, which by their recurrence produce a band through the axis. This difference in longitudinal section would probably escape no trained observer, but its significance can be appreciated only when interpreted in terms of the complete organism.

The minute wall structure of *Triticites*, though it does not seem to differ from that of *Fusulina*, deserves to be noticed. The wall in these shells is composite, apparently consisting of two substances of different character, or, at all events, of different density. Thus, when thin sections are examined, three different tints, with more or less well-marked boundaries, are seen, namely, the transparent calcitic filling of the chambers, the translucent substance of which most of the wall is composed, and an outer opaque layer whose distribution will be described somewhat carefully. This opaque layer is much thinner than that which is translucent, and seems to represent merely an external coating upon the upper and front sides of each chamber wall. It usually appears as a strong dark line in thin sections, which defines the translucent wall of one chamber from that of the next, and it forms a plane of dehiscence along which the chambers and volutions tend to separate. A certain amount of variation is manifest by this layer and its conduct in the partitions is different from that in the revolving wall, an indication of individuality in these structures of which there is further evidence. In the revolving wall it occasionally happens, chiefly in local areas, that no intensification of tint is seen along the outer surface, the whole wall being practically uniform. In other instances an intensification occurs on the inner side nearly equal to that of the outer, but as a rule, from which exceptions are but few, sections clearly show a dark coating upon the outer surfaces of the revolving wall. This layer is seen to be continuous from the revolving wall to the partitions and it thus defines to the eye the limits of each chamber from that adjacent to it. The growth of the shell is, therefore, seen to be the result of a repetition of similar stages, each of which consisted of a prolongation of the shell first in a

revolving and then in an axial direction. While as a rule the dark line of the dense layer defines the external surface of the partition as well as of the revolving wall, the thick inner layer apparently being continuous from one to the other, occasionally it interrupts the latter and as it assumes an axial direction fans out and either divides, so as to bound both sides of the partition, or spreading, involves it in a nearly uniform dark tint. In this case obscure radial lines, probably of structural origin, can sometimes be made out. The partitions, as we shall shortly see, have otherwise a different structure from the revolving wall. The distribution and behavior of this dark coating seems to me to indicate that it is an original and intrinsic feature of the shell structure, and that it does not represent the contact between two walls nor the plane along which testaceous material was deposited from two sides. Somewhat in contradiction, however, stands the fact that where the walls have become detached the dark layer is often not conspicuously

3

Transverse section. × 15.

4

Transverse section. × 25.

5

Microscopic structure. × 40.

retained upon either of them. Figs. 3 and 4, drawn from *Triticites secalicus*, show the general microscopic structure of the wall, the thin outer dense layer, and the thick inner translucent layer. They show the inner wall as completely surrounding the interior of the chamber. While not of rare occurrence, it is more common for the inner layer to be developed only on the upper and outer portions of the chamber wall, the lower and inner boundary being formed by the dense outer layer of the volution and chamber preceding. It is evident that the complete inner layer, if it is extended from end to end, would cut off all communication between adjacent chambers (except through the pores). The formation of this layer, therefore, over the back and lower walls is probably due to subsequent deposition.

Part of the translucent wall is thickly penetrated by opaque rods or tubuli, whose direction is normal to its two faces, and it is this structure which has caused *Fusulina* to be described as strongly perforate. These rods or tubes are always considerably darker than the translucent wall which they pervade and are as a rule of somewhat lighter tint than the dense outer layer. They usually increase in size inward and taper toward

the opaque layer, and while in some instances they reach and connect with the latter, for the most part they diminish and disappear before completely penetrating the translucent wall. They have the same appearance whether the specimen is cut lengthwise or transversely, and their cross section was probably circular. In their distribution these rods or tubes seem to be confined entirely to the revolving wall. Occasionally they can be seen to extend part way around the turn to where the wall becomes radial, but I have never seen them in the partition wall itself. Fig. 5 represents a section through part of the revolving wall of *Triticites secalicus*. The upper margin of the figure is the outer margin of the wall. The dark lines represent what has usually been interpreted as pores or tubes. These structures can not be seen in the radial walls.

In section, therefore, the revolving wall is seen to be barred off into nearly equal stripes of opaque and translucent shades, and of these it is clear that the translucent ones represent the shell and the opaque ones what have been considered pores.

Carpenter described the minute structure of "*Fusulina*" in 1870, and his conclusions have been followed or concurred in by most subsequent writers. It is interesting to note that his investigations were made upon specimens from Iowa which with great probability belonged not to *Fusulina* but to *Triticites*. One can hardly doubt that he also studied specimens of real *Fusulina*, and it is difficult to understand why he disregarded the differences which have led me to distinguish *Triticites* as a distinct group. Though he does not mention or figure the dark layer which coats the walls upon their outer side and which in sections defines the outline of each chamber, and though other writers have not, whose work has come into my hands, I am quite satisfied as to its existence and persistence.* The interpretation of its significance, on the other hand, is a matter of uncertainty. The presence and conduct of this dark superficial layer and its relation to the so-called tubuli have led me to entertain some doubt as to whether the shell in this genus is as usually stated, perforate.

Carpenter remarks upon the complexity of the partition walls in the terminal portions of *Triticites* in the following terms: "The irregularities which are noticeable in *sections* made either longitudinally or traversely through the terminal portions of the shell, seem explained by the disposition of the alar prolongations which is revealed by *fracture;* for this shows that the alar prolongations, as they pass to a distance from the median plane, tend to interdigitate with each other,

* Material of both *Fusulina* and *Triticites* has been examined, and from a number of localities and horizons sufficient to show that these characters are constantly present and are not the result of peculiar preservation.

in such a manner as to produce great apparent confusion when they are brought into view by section."* While this is perhaps equally true of *Fusulina*, the simplicity of the partitions in *Triticites* over their median portion renders their complexity near the ends peculiarly striking. From the passage above quoted, from Carpenter's figures, and from the localities and horizons from which his American specimens were obtained, there can be no doubt that they belonged to *Triticites*, instead of to *Fusulina*.

I am in some uncertainty about the taxonomic value which should be given to the differences above noted between *Fusulina* and *Triticites*. It is evident that they are of degree only, though very marked in the case of the forms under discussion, intermediate stages being unknown. I would regard *Triticites* in any other group as a good subgenus, though probably no more; but among forms whose simple structure puts a certain limit upon differentiation, it seems that somewhat different standards should be employed, and I believe that the group of *Triticites* can be given generic rank.

The type of *Triticites* is not a new species. In 1823 Say† described two species from Kansas and Nebraska under the name of *Miliolites secalicus* and *Miliolites centralis*, which from evidence intrinsic and extrinsic belong without question to the group of fossils for which the name *Fusulina cylindrica* has since come into general use. J. W. Beede‡ was, I believe, the first to recognize the real character of *Miliolites secalicus* and to revive this specific name for the American form, but he did not discriminate it from *Fusulina cylindrica* Fischer-de-Waldheim, which he relegated to synonymy. While I had little doubt that the American species was distinct from the Russian one, I have continued to use for it the name *Fusulina cylindrica*, because it seemed to me undesirable to disturb the current terminology until several essential points could be determined with reasonable finality. In the present paper I have sought to show that the American form is not only specifically distinct from *Fusulina cylindrica*, but can probably be referred to a different genus, for the type of which *Triticites secalicus* is selected. This species was first described from the Missouri River near the Platte. The material upon which my interpretation of *Triticites secalicus* is based, and upon which the term *Triticites* immediately rests, was obtained from the Platte River near its junction with the Missouri. The locality and horizon, therefore, can be said to be essentially the same,

* Monthly Microscop. Jour., vol. iii, 1870, p. 182.

† Account of an Expedition from Pittsburgh to the Rocky Mountains, etc., under Major Stephen H. Long, vol. i, 1823, p. 151, footnote.

‡ Univ. Geol. Surv. Kansas, Rept., vol. 6, 1900, p. 10.

and as my material agrees with Say's description as far as it goes, I have little doubt that it is the same species for which the name was first employed. My investigations have been carried sufficiently far to show that most if not all of the so-called *Fusulinas* of the Mississippi Valley belong to *Triticites*. I am not prepared to express an opinion as to whether several or, as has generally been assumed, but a single species occurs there. The second species described by Say, under the name of *M. centralis*, is doubtfully distinguished by the characters pointed out by its author. Say's description of *Miliolites secalicus* is framed in the following words, and can be amplified from the descriptions and figures here presented:

"29. On the Missouri near the Platte occur masses of rock, which seem to be almost exclusively composed of a remarkable petrifaction, belonging to the family of concamerated shells. This shell is elongated, fusiform, and when broken transversely, it exhibits the appearance of numerous cells disposed spirally as in the *Nummulite*, but its longitudinal section displays only deep grooves. The shell was therefore composed of tubes or syphons, placed parallel to each other, and revolving laterally as in the genus *Melonis* of Lamarck, with which its characters undoubtedly correspond. But as in the transverse fracture, its spiral system of tubes cannot be traced to the center in any of the numerous specimens we have examined, it would seem to have a solid axis, and consequently belongs to that division of the genus that Montfort regards as distinct, under the name of *Miliolites*, which seems to be similar to the *Fasciolites* of Parkinson, and altogether different from the Miliolites of Lamarck. Our specimens are conspicuously striated on the exterior, which distinction, together with their elongated fusiform shape, sufficiently distinguish then as species from the *sabulosus* which Montfort describes as the type of his genus. No aperture is discoverable in this shell, but the termination of the exterior volution very much resembles an aperture as long as the shell.

The length is three-tenths of an inch. And its greatest breadth, one-twelfth.

We call it *Miliolites secalicus*, *Say*. Mr. T. Nuttall informs me, that he observed it in great quantities high up the Missouri.

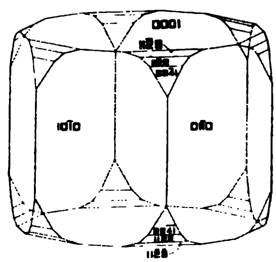
In the same mass were some segments of the Encrinus, and a Terebratula with five or six obtuse longitudinal waves."

Art. XXII.—*Prismatic Crystals of Hematite*; by G. W. McKee.

The common forms for hematite crystals are rhombohedra and scalenohedra. Prismatic faces are seldom well developed. The basal pinacoid is still rarer. Specimens of well crystallized hematite showing crystals of an unusual habit were obtained recently from Dr. A. E. Foote, Philadelphia. These specimens are reported to be from Guanajuato, Mexico. The crystals, which are very small, seldom more than a millimeter in diameter, are well formed and possess a bright metallic lustre such as is characteristic of the specimens from Elba. They occur spread in a layer over the surface of a much decomposed rock, which is probably a rhyolite.

A few of the best crystals were selected for measurement on a Goldschmidt two-circle reflecting goniometer. Some of

1



them showed combinations of the prism $\{10\bar{1}0\}$ and base $\{0001\}$, while others presented in addition to these forms several pyramids of the second order. In all cases, however, the most prominent forms were the prism $\{10\bar{1}0\}$ and the base $\{0001\}$. These faces ordinarily play a very subordinate part in the crystallization of hematite and by their prominence here we obtain a distinct prismatic crystal habit hitherto rarely recorded for hematite. The results of the measurements on two crystals are given in detail and along with them, for purposes of comparison, the calculated results for the symbols deduced. If we consider the pyramids as of the second order then the prism becomes the prism of the first order. All the forms observed here are already well known, the complete list being as follows:—$\{0001\}$, $\{10\bar{1}0\}$, $\{11\bar{2}8\}$, $\{11\bar{2}2\}$, $\{22\bar{4}1\}$.

CRYSTAL No. I.

No.	Measured. ρ	ϕ	Calculated. ρ	ϕ	Symbol.
1	0°	....	0°	....	$\{0001\}$
2	90°	0° 15′	90°	0°	
3	90°	0° 2′	90°	0°	
4	90°	0° 8′	90°	0°	
5	90°	0° 15′	90°	0°	$\{10\bar{1}0\}$
6	90°	0° 10′	90°	0°	
7	90°	0° 8′	90°	0°	
8	72° 21′	29° 52′	72° 22′	30°	$\{22\bar{4}1\}$
9	38° 36′	28° 2′	38° 11′	30°	
10	37° 15′	27° 46′	38° 11′	30°	
11	38° 24′	30° 25′	38° 11′	30°	$\{11\bar{2}2\}$
12	37° 15′	30° 40′	38° 11′	30°	
13	40° 6′	28° 55′	38° 11′	30°	

CRYSTAL No. II.

No.	Measured. ρ	ϕ	Calculated. ρ	ϕ	Symbol.
1	0°	....	0°	....	$\{0001\}$
2	90°	0° 14′	90°	0°	
3	90°	0° 2′	90°	0°	
4	90°	0° 17′	90°	0°	$\{10\bar{1}0\}$
5	90°	0° 3′	90°	0°	
6	90°	0° 1′	90°	0°	
7	72° 22′	29° 31′	72° 22′	30°	$\{22\bar{4}1\}$
8	72° 22′	29° 45′	72° 22′	30°	
9	12° 30′	29° 45′	11° 7′	30°	$\{11\bar{2}8\}$

The accompanying drawing, fig. 1, was prepared from a gnomonic projection showing the projection points of the normals of an idealized crystal representing all the forms obtained. The relative central distance for the different forms indicated in the drawing corresponds very closely with that of the crystals examined.

Hematite crystals showing the prismatic habit have been described by Pirsson.* His specimens were also obtained from Mexico and were peculiar in their association with cassiterite, which was frequently contained in the hematite as inclusions. Some of the Guanajuato crystals were finely powdered and treated with hot concentrated hydrochloric acid; the resulting solution was tested in the usual method and was found to be free from tin.

These observations were made in the Mineralogical Laboratory of the University of Toronto.

* This Journal, vol. xlii, pp. 407, 1891.

Department of Mineralogy, University of Toronto,
December, 1903.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *An Attempt at a Chemical Conception of the Universal Ether.*—D. J. Mendeléeff, the celebrated author of the Periodic System of the Elements, has published some speculations in regard to the ether.

From a realistic standpoint it is inevitable that weight and chemical individuality should be ascribed to the ether. It must be a distinct chemical substance so light that it can escape the attraction of the fixed stars by the swiftness of the motion of its molecule; it can have no chemical affinity; its power of diffusion must be so great that it can penetrate all bodies, and thus elude being weighed, although it actually possesses a very minute weight. It can be assumed to be an inactive gas of the argon-helium series with very small atomic weight. By means of *inter*polation the author has predicted new elements (scandium, gallium, and germanium), and he ventures to make *extra*polations below helium. In the place before hydrogen he assumes the existence of an inactive element, which possibly is identical with *coronium*, with an atomic weight estimated at about 0·4. The ether must have a still smaller atomic weight, the value of which, $<0{\cdot}17$, on account of the double extrapolation, is very uncertain. For the ether as an element the author proposes preliminarily the name *Newtonium*. He calculates also, that, in order that it might escape from the largest bodies of the universe, the atomic weight of the ether might necessarily be as small as one-millionth of that of hydrogen.

The author gives, in addition, a realistic explanation of radioactivity by supposing that the radio-active elements (U, Th, Ra) on account of their abnormally high atomic weights are capable of holding a relatively large number of the ether atoms about their large centers of mass, without combining with them chemically, and that the arrival and departure of the ether molecules is accompanied by disturbances in the ethereal medium which produce the rays of light.—*From an abstract in Chem. Central-Blatt*, 1904, i, 137. H. L. W.

2. *Gold Fluoride.*—Since gold frequently accompanies fluor-spar in natural deposits, it seemed possible that gold fluoride might play a part in the formation of such deposits. Therefore, Victor Lenher has undertaken a study of the relations of gold and fluorine. Finely divided oxide of gold was found to be entirely unattacked by hydrofluoric acid, even in the presence of nitric acid. It was found to be impossible to prepare gold fluoride by the interaction of silver fluoride and gold chloride, for the substances reacted as follows :

$$AuCl_3 + 3AgF + 3H_2O = 3AgCl + Au(OH)_3 + 3HF.$$

Since it seemed that water decomposed gold fluoride as soon as it was formed, attempts were then made to carry out the same reaction in the presence of anhydrous solvents, such as ether, chloroform, carbon tetrachloride, etc., but the substances under experiment were either insoluble in these solvents, or were decomposed by them, so that this method did not succeed. Gold fluoride appears, therefore, incapable of being formed by ordinary reactions, although Moissan, by the action of fluorine gas upon gold at a red heat, obtained a yellow, hygroscopic substance which easily decomposed into the metal and fluorine. It is remarkable that fluorine, the most active of all the elements, should have so slight an affinity for gold.—*Jour. Amer. Chem. Soc.*, xxv, 1136.
H. L. W.

3. *The Separation of Radium from Barium.*—Heretofore the only available method for obtaining products richer in radium from mixtures of barium and radium salts, has been the fractional crystallization of the chlorides or the bromides. MARCKWALD has now found that it is possible to obtain an enrichment in radium by agitating a concentrated solution of the salts with one-fifth of its weight of one per cent sodium amalgam. Barium and radium amalgam is thus formed in which the proportion of radium is much increased over that in the original mixture. By repeating the operation with the residual liquid, after it has been previously neutralized, successive products are obtained which gradually diminish in activity. The method as thus employed offers no advantages over the method of fractional crystallization, since it also is a fractionating process, but it is interesting in showing for the first time a difference in chemical behavior between barium and radium.—*Berichte*, xxxvii, 88. H. L. W.

4. *The Dissociation of the Alkaline Carbonates.* — Having previously shown that lithium carbonate can be completely volatilized in a vacuum above 1000° in consequence of its dissociation into carbon dioxide and lithium oxide, P. LEBEAU has studied the behavior of the carbonates of sodium, potassium, rubidium and cæsium under the same conditions. He has found that all of these carbonates are dissociated above 800° with the formation of carbon dioxide and a volatile alkaline oxide, so that a sort of volatilization of the carbonates takes place. When the alkali metals are divided into two sub-groups, lithium and sodium comprising the first, and potassium, rubidium and cæsium the second, it found that the ease of dissociation decreases with the atomic weight in the first sub-group, and increases with it in the second. —*Comptes Rendus*, cxxxvii, 1255. H. L. W.

5. *Combination of Saccharose with Certain Metallic Salts.*— It is known that cane-sugar unites with sodium chloride, bromide and iodide, as well as with potassium chloride, to form crystalline compounds. D. GAUTHIER has recently succeeded in obtaining a number of other similar compounds which are well-defined. The following substances are described :

$C_{12}H_{22}O_{11}\cdot KI\cdot 2H_2O$
$C_{12}H_{22}O_{11}\cdot LiCl\cdot 2H_2O$
$C_{12}H_{22}O_{11}\cdot LiBr\cdot 2H_2O$
$C_{12}H_{22}O_{11}\cdot LiI\cdot 2H_2O$
$C_{12}H_{22}O_{11}\cdot CaBr_2\cdot 3H_2O$
$C_{12}H_{22}O_{11}\cdot CaI_2\cdot 3H_2O$
$2C_{12}H_{22}O_{11}\cdot BaCl_2$
$2C_{12}H_{22}O_{11}\cdot BaBr_2$
$2C_{12}H_{22}O_{11}\cdot BaI_2$

It is proposed to study the properties of these bodies in the future, and also to attempt the preparation of compounds with other salts.—*Comptes Rendus*, cxxxvii, 1259. H. L. W.

6. *The Density of Chlorine.* — New determinations of the density of chlorine gas have been made by MOISSAN and JASSONEIX. The method of Dumas was employed, which consists in filling a globe having a slender neck with the gas, by displacement, sealing the neck by fusion, and weighing. Considerable difficulty was experienced in obtaining pure chlorine; even liquid chlorine was found to hold other gases in solution, and the best results appear to have been obtained by using chlorine which had been previously solidified by cooling. As an average of the best results, the density 2·490 at 0° is given. This number agrees very closely with Leduc's result, 2·491, published in 1897.—*Comptes Rendus*, cxxxvi, 1198. H. L. W.

7. *The Doppler Effect in Electrical Sparks.*—If metallic particles are torn off from the electrodes between which a spark is produced and are lighted, one would expect on looking in the direction of the spark with a suitable optical arrangement to see, according to Doppler's principle, a displacement of the lines of the spectrum. AUG. HAGENBACH uses two sparks in front of the slit of a spectroscope. The current was directed through these gaps in opposite directions. In one experiment Michelson's echelon spectroscope was used with mercury lines. The results were negative; and the author concludes that there is no displacements greater than 0·01 A.-unit ; if the Doppler principle holds for the case of electric sparks, the velocity of the metallic particles cannot be greater than this value indicates. In another experiment a Rowland grating was used and a similar result was reached. The author's results do not agree with those obtained by Schuster and Hemsalech, or with those of Mohler, in regard to the velocity of the shot off particles. These authors found a large velocity for such particles.—*Ann der Physik*, xiii, pp. 362–374. J. T.

8. *Effect of Temperature on Ionization by Röntgen Rays.*—R. K. MCCLUNG, working in the Cavendish laboratory, believes that he has proved conclusively that, in a given volume of gas, kept at a constant density, the amount of ionization produced by Röntgen rays of a given intensity is independent of the temperature of the gas.—*Phil. Mag.*, 1904, pp. 81–95. J. T.

9. *The Arc in Metallic Vapors in an Exhausted Space.* — Dr. E. WEINTRAUB has conducted, in the laboratory of the General Electric Company at Schenectady, an exhaustive series of experiment on the Cooper-Hewitt mercury lamp.

(1) By a series of experiments it was shown that in the process of starting an arc the cathode plays an important role, so that a certain change must take place on its surface before the arc can start; the anode receives the current without any previous excitation.

(2) Starting from the recognition of this role of the cathode, a new method has been devised for an instantaneous starting of the passage of a moderate voltage current through the space separating the electrodes, and this no matter how long this space is.

(3) The properties of the mercury arc have been studied, and a number of differences in the behavior of the cathode and the anode, beside the one mentioned above, stated.

(4) The behavior of amalgams, as well as pure alkali metals, has been investigated, and the complete analogy between the behavior of the arc in their vapors and that of the mercury arc shown.

(5) Different ways have been found to cause an alternating current to pass through mercury vapor in form of an arc.

(6) On the basis of this a theoretically almost perfect rectifier for conversion of alternating current into steady direct current was developed.—*Phil. Mag.*, Feb., 1904, pp. 95–124. J. T.

10. *Electricity and Magnetism. An Elementary Text-Book Theoretical and Practical*; by R. T. GLAZEBROOK. Pp. viii + 440. Cambridge, 1903 (The University Press).—This volume, like the others by the same author in the Cambridge Physical series, is based on the first year work in physics as given at the Cavendish laboratory. Also, like its predecessors, it is a type of text-book little used in this country. The ordinary method of carrying on instruction in physics is threefold; first, by means of a lecture course, second, by laboratory work, and third, by a quiz. As an aid to the two latter branches, the common practice in this country is to provide the student with two separate text-books—one treating the theory of the subject from a general standpoint and the other containing directions more or less minute for a certain number of experiments. On the other hand, the English practice, as exemplified in the book before us, is to combine the two books into one. That this method has certain advantages in giving the student a better perspective is obvious; and that this view is coming to be more appreciated here, is evidenced by the volume on Mechanics and Heat which has recently appeared from the Ryerson laboratory at Chicago. (See below.)

The development of the doctrines of electricity and magnetism, together with their more important applications, is carried out admirably along the lines which Maxwell made classic. The experiments are well chosen and numerous examples are scattered

through the book to aid in driving the principles home. The most recent developments in the science also receive adequate attention, the last two chapters being on Hertzian waves and the recent work on the discharge through gases. The demonstrations and deductions are often of the unsatisfactory nature which the necessity of excluding the Calculus makes unavoidable. But aside from this defect, which is inherent in any presentation written for students in a like state of mathematical ignorance, this book appears to the writer to be the most satisfactory one that has come under his notice. L. P. W.

11. *Mechanics, Molecular Physics and Heat.* A Twelve Weeks' College Course; by R. A. MILLIKAN. Pp. 242. New York, 1903 (Ginn & Co.).—This book is a combined text-book and laboratory manual. It represents an attempt to attain a closer coördination between the laboratory, the class room, and the lecture room, and as such is to be highly commended. No one who has taught elementary Physics can fail to be in sympathy with this aim or to be interested in the way in which the problem is attacked in the Ryerson Laboratory. The writer can recommend the preface of this book to all who are interested in the very serious problem of how best to teach Physics.

Judging from personal experience with students of the maturity implied, it would seem as if too much knowledge were assumed. Neither velocity nor mass are explicitly defined. The logical sequence of the development of the principles of mechanics is not all that could be desired. On the other hand, the selection and arrangement of the experiments and problems is excellent. On the whole it would seem that while the book is well adapted to the system of instruction in use at Chicago, its usefulness elsewhere will be limited—unless that system comes to be generally adopted. L. P. W.

12. *Treatise on Thermodynamics;* by MAX PLANCK. Translated by ALEXANDER OGG. Pp. xii + 272. New York (Longmans, Green & Co.).—This is an excellent translation of Professor Planck's well-known work on thermodynamics which appeared in 1897, embodying in a connected treatment of the subject the author's many original contributions to this branch of science. Like all of Planck's work, it is marked by strict and satisfactory logical development and by a clear recognition of the nature, authority and limitations of our knowledge of the general principles upon which the science is based. The treatment of the Second Law, while essentially the same as that employed by Clausius, Kelvin and Maxwell, is, at the same time, original in its point of view and is very illuminating; it should not be neglected by any serious student of thermodynamics. Irreversible processes receive a larger share of attention than is usual—a most commendable feature in a text-book since all actual thermodynamic processes are irreversible, and it is, therefore, very essential that the knowledge of the working physicist and engineer should not be confined to the ideal reversible case. The book also gives a large amount of space to the discussion of the applications of thermodynamics to the problems of chemical equilibrium and it should

be very useful to the student of physical chemistry. From the pedagogical point of view, one could wish that the author had not confined himself so strictly to analytical methods and that more diagrams and geometrical illustrations had been employed; but after all this is largely a question of taste. H. A. B.

II. Geology.

1. *The Coral Reefs of the Maldives;* by Alexander Agassiz. Mem. Mus. Comp. Zool. Harvard College. Pp. i–xxv, 1–168, 82 pls. One volume text. One volume plates.—Parts of December, 1901, and January, 1902, was spent by Professor Agassiz in exploring the Maldives (for sketch of the work of this expedition see this Journal, xiii, 297). All of the important atolls were examined and more than eighty soundings were taken. The variety exhibited by the small islands points "to the uselessness of our present definition of atolls. There is every possible gradation between a curved crescent-shaped open bank of greater or less size and an absolutely closed ring of land surrounding a lagoon without direct communication with the sea. The evidence . . . shows that reef corals will grow upon any foundation where they find the proper depth and that local conditions will determine their existence as fringing reefs, barrier reefs or atolls." In most particulars the work of Gardiner is substantiated (this Journal, xvi, 203), but the soundings reveal considerable irregularity in the depth of the plateau, and the conclusions drawn by Gardiner from the supposed existence of a great level central plateau may need revision. The soundings show also that Darwin's suggestion that the Maldive Archipelago originally existed as a barrier reef of nearly the same dimensions as that of New Caledonia, is not borne out.

This is the last of a series of monographs on Coral Reefs, but Professor Agassiz promises a *résumé* of results obtained from study of all the important coral regions of the Atlantic, Pacific and Indian Oceans.

2. *Note on the Classification of the Carboniferous formation of Kansas;* by Henry S. Williams. (Communicated.)—In the brief review of Bulletin 211 of the U. S. Geological Survey (this Journal, xvii, 175), a few facts were not given which perhaps should be stated in order to give credit where credit is due, and the quotation on p. 176 is by its incompleteness somewhat misleading, hence the following statement:

A further examination of Bulletin No. 211 of the United States Geological Survey shows that the following formations, viz: Elmdale, Neva, Eskridge, Garrison, Matfield, and Doyle had previously been given these names by Prosser and Beede and were more fully described by Prosser. Their description was published by Prosser in the Journal of Geology, vol. x, pp. 708–715, which number appeared during the first week of December, 1902, eleven months before the publication of Bulletin No. 211.

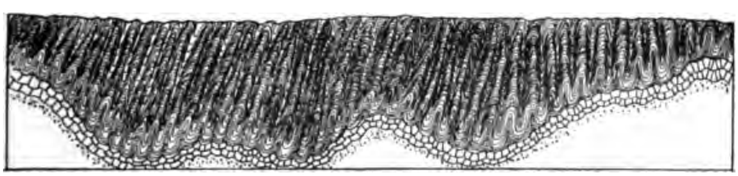
Mr. Girty stated that "the evolution of the latest from the

earliest faunas in the section" is shown "to have been a progression from a brachiopod to a pelecypod facies. The gradual character of this replacement has been remarked by most paleontologists who have studied the faunal succession. It is without marked interruption at any point, so that subdivisions appropriate for recognition are not clearly apparent, and there is room for differences of opinion as to where delimitation should be made."

3. *Einführung in die Paläontologie;* von Dr. GUSTAV STEINMANN. Pp. 1–466, figs. 1–818. Leipzig, 1903 (Wilhelm Engelmann).—This elementary treatise on paleontology is written by one of the authors of the "Elemente der Paläontologie" of Steinmann and Döderlein published in 1890, and appears to be an abbreviation and revision of that work, using the same illustrations, with an addition of fifty pages on fossil plants, and numerous new figures. The reduction of a work attempting to introduce the reader to a knowledge of plants and animals of past geological time to 466 pages, makes it necessary to mention only the more conspicuous families, while for each family only the more characteristic are named and very brief descriptions given. It is too technical for general reading and not complete or full enough to be of much use in the laboratory, but it may serve as a means of gaining a superficial knowledge of the names of the more conspicuous genera met with in treatises on geology and thus be of use to the geologist or general student as a means of gaining definite ideas of the forms of fossils. It is well printed and the illustrations are chosen to give a comprehensive idea of the diagnostic characters of the forms illustrated. H. S. W.

4. *The Structure of the Piedmont Plateau as shown in Maryland;* by EDWARD BENNETT MATHEWS.—Attention is called to the fact that fig. 1, p. 150, in the article by E. B. Mathews, is printed in inverted position. The figure is here repeated inserted in its correct position.

1



5. *Western Australia Gealogical Survey.* — Three bulletins have recently been issued as follows:

No. 8. Lennonville, Mount Magnet, and Boogardie, Murchison Goldfield; by CHAS. G. GIBSON. 33 pp. with map.

No. 9. Geological Features and Mineral Resources of Northampton; by A. GIBB MAITLAND. 28 pp. with map and sections.

No. 10. Descriptions of Carboniferous fossils from the Gascoyne District, Western Australia; by R. ETHERIDGE, JR., 41 pp. 6 pls.

6. *The Evolution of Earth Structure;* by T. MELLARD READE. 342 pp., 40 pls., 1903. (Longmans, Green & Co.)—In this volume Mr. Reade has brought together his views upon the causes of crustal movements. The volume falls naturally into two divisions, first the causes of broad vertical movements without tangential thrust, commonly known as epeirogenic; and secondly, the causes of tangential thrusts and their relations to mountain building.

However much geologists may differ from some of the conclusions of the work, the author's method must be regarded as admirable, first presenting generally conceded facts, secondly, framing a hypothesis and, thirdly, showing its mechanical possibility. Thus it may be said that Mr. Reade has developed true causes, but it remains to be seen from further study and generalizations if they are quantitatively sufficient, or if there are other more potent factors. Especially would possible changes of view upon the nature of the earth's interior modify his conclusions.

Taking up the first division of the volume, that concerning vertical crustal movements, Reade cites familiar examples of coastal oscillations and shows the incompetence of the principle of isostacy to initiate such movements or to give them an oscillatory character. The author maintains that isostatic equilibrium is true as a broad principle, as shown by the fact of the specific gravity of the continental crust and subcrust being less than that beneath the oceans, but relates this to diastrophic movements by assuming that slight regional changes of volume but not of mass occur deep within the earth.

Lateral shiftings within the earth would also result in such movements, but no cause has been shown why within a solid earth matter should so shift, especially as work would be done in lifting the continental masses. In favor of the view that the movements are due to slight volume changes without changes of mass or lateral shifting, Reade discusses the irregular changes of density which take place during the cooling of a bar of iron and the change in density due to magnetization.

The author believes that most of the fluctuations of volume take place within a depth of 500 miles from the surface in what he terms the "sphere of igneous magma" and "the condition of the matter may be normally solid, but potentially fluid, or actually fluid when nearing the surface." Following this statement of causes, the view is expressed from a consideration of the sea coasts that the continents as a whole are at present in an era of low level. An examination of the infrequency of deep sea soundings and the discovery of occasional rapid variations in depth leads to the further conclusion that there is merely negative evidence for the prevalent belief in the smoothness of the ocean floor and the permanence of continents, but that in regions removed from rapid sedimentation more careful soundings may reveal bottoms which still show forms of subaerial erosion. A considerable degree of impermanence of continents is further shown by a consideration of basins of sedimentation, and as bearing upon this problem two previous papers, "Denudation of the Two

Americas" and "The North Atlantic as a Geological Basin" are reprinted.

Turning to the author's views on orogeny, the belief is expressed that periods of mountain-making are related to the formation of new land areas, the orogenic cause consisting in alternate expansions and contractions, and being essentially that developed in his volume "The Origin of Mountain Ranges," 1886. Further details are added, however, giving the results of laboratory experiments upon models of various forms. These show how with circumferential compression strata may be folded into parallel crescentic or radiating crescentic folds with minimum mass deformation of the beds. The resulting forms are developable surfaces, made by simple bendings of the strata. An initial bias is shown to be an important factor in determining the form of yielding, and the whole is an important contribution showing the effects of compression acting in two or more directions simultaneously.

While Reade has demonstrated the adequacy of repeated expansions and contractions in producing deformations in several substances, notably to the distortions of a lead-lined sink, to the reviewer's mind it is far from being demonstrated quantitatively sufficient to result in mountain-making, chief among the objections being first, that there is no evidence of the numerous widespread fluctuations of internal temperature which would be necessary for the amount of shortening shown in the chief mountain ranges; secondly, that the unequal heating of higher and lower beds would result in differential movement and friction in transmitting the thrust to a distance, lessening the effective thrust of the expanding stratum and tending to produce local vertical mass deformation rather than distant folds. Thirdly, this theory does not account for the deferment of mountain-making for millions of years, during which time progressive sedimentation and subsidence is going forward, followed by a relatively brief epoch of crustal yielding.

In the latter part of the book the author devotes two chapters to faulting and to slaty cleavage. J. B.

III. Miscellaneous Scientific Intelligence.

1. *Smithsonian Institution*, S. P. Langley, Secretary, *Report for year ending June 30, 1903*.—The annual report of the Smithsonian Institution gives a summary of the work done in the several fields of activity. In the appendixes to the general report are more detailed statements regarding work of the National Museum, the Bureau of Ethnology, etc. The Museum is to have a $3,500,000 building in which its large and rapidly increasing collections may be properly stored. The Astrophysical Observatory has made special bolographic studies of the absorption of the solar rays. The atmosphere "has been more opaque than usual within the present calendar year, so much so as to reduce the direct radiation of the sun at the earth's surface by about 10 per cent throughout the whole visible and infra-red spectrum, and by more than double this amount in the blue and

violet portions of the spectrum." A new determination of the temperature of the sun gives 5920° C. For the study of sun spots, a horizontal reflecting telescope of 140 foot focus and 20 inch aperture, provided with a new form of coelostat, has been constructed.

2. *Smithsonian Miscellaneous Collections, Quarterly Issue.* Vol. I, Pts. 1 and 2.—The Quarterly issue of the Smithsonian Miscellaneous Collections is designed to afford a medium for early publication of the results of researches conducted by the Institution and for reports of a preliminary nature. The Quarterly Issue will not supersede but will form part of the regular series of the Smithsonian Miscellaneous Collections. It will be published about the first of January, April, July and October. Each number will consist of about 144 pages and will be suitably illustrated. The present number contains seventeen articles, among them the description of the new telescope and coelostat, by C. G. ABBOTT, mentioned in Secretary Langley's report (see above).

3. *Weather Bureau, U. S. Department of Agriculture.*—The two following volumes have recently been issued :

BULLETIN L. Climatology of California ; by ALEXANDER G. MCADIE. 261 pp., 31 figs., 12 pls. The great variety of climates existing within California and the numerous abnormalities exhibited, e. g., at San Francisco, makes the description of the meteorological conditions within the State of more than local importance. Professor McAdie discusses the controlling climatic factors of the Pacific Coast region, after which come descriptions of conditions prevailing in different parts of California. The chapter on Fog is particularly valuable, as the conditions at San Francisco are unusually favorable for the study of this phenomenon.

BULLETIN No. 33. Weather Folk Lore and Local Weather Signs ; by EDWARD B. GARRIOTT. 183 pp., 21 pls. Many of the everyday sayings regarding weather signs are true and have come from careful observation on the part of sailors, farmers and other men. Many weather proverbs, on the other hand, are ridiculous. Professor Garriott has classified and discussed these sayings and gives the true weather signs for 143 stations within the United States.

4. *Scientia*, No. 22. — The latest addition to this valuable series is entitled : Diagrammes et Surfaces Thermodynamiques, par J. W. Gibbs. The translation was made by M. G. Roy of the University of Dijon and an introduction is given by M. B. Brunhes of the University of Clermont.

OBITUARY.

Dr. CHARLES EMERSON BEECHER, Professor of Paleontology in Yale University, died suddenly of heart failure on February 14, in his 47th year. A biographical notice will appear later.

Professor KARL ALFRED VON ZITTEL, the eminent paleontologist of the University of Munich, died on January 6, at the age of 65.

THE

AMERICAN JOURNAL OF SCIENCE

[FOURTH SERIES.]

ART. XXIII.—*Criteria relating to Massive-Solid Volcanic Eruptions*; by ISRAEL C. RUSSELL.

SINCE Monte Pelé presented geologists with a marvelous illustration of the ability of a volcano under certain special conditions to force a mighty column of solid lava vertically upward into the air from the summit of its conduit, the question has frequently been asked: Are other examples of a similar nature known? The reply is that no similar shaft of solid rock has been seen to ascend from the summit of a volcano, but evidences of former protrusions of a like nature have been recognized, and as it seems, when search is made aided by the experience recently gained on Martinique,* the records of massive-solid eruptions that have occurred in the past will perhaps be found to be somewhat common.

In order that the appearance of the example of a massive-solid volcanic eruption which will no doubt in the future be taken as the type of its class, may be fresh in mind, the reader should turn to the admirable photographs of the "obelisk" of Monte Pelé, published by Dr. E. O. Hovey, in this Journal, October, 1903.

The striking object lesson furnished by the growth of the obelisk of Pelé has already stimulated geologists to search for the records of similar occurrences in other regions. Results in this direction have been reported by Hovey,† who during a continuation of his important explorations in the Lesser Antilles, found that the Grand Soufrière of Gaudeloupe, and the prominent central peak on the Island of Saba,

* Descriptions and illustrations of the obelisk of Pelé by E. O. Hovey, have been published in this Journal, October, 1903, vol. xvi, pp. 269-281; and in Science for November 13, 1903, vol. xviii, pp. 633-634. These articles contain references to the publications of other observers. See, also, "The Pelé Obelisk," by Israel C. Russell, in Science for December 18, 1903, vol. xviii, pp. 792-795.

† This Journal, vol. xvi, October, 1903, p. 281.

bear evidence of being the result of massive-solid eruptions like that Pelé is now experiencing. "This is especially clear," writes Hovey, "in the case of the Grand Soufrière, the cone of which rises above an old crater-rim which it has buried in the same way that Monte Pelé is now striving to bury its surrounding crater-walls." The details on which this conclusion is based have not yet appeared in print, but will no doubt when published furnish a valuable contribution to the history of volcanoes.

Sir Richard Strachey, in a note in Nature,* presents a sketch, but unfortunately not accompanied by a description, of certain prominent columns in the Deccan trap region of India, which have at least a superficial resemblance to the obelisk of Pelé. The columns represented in the sketch, however, appear to be examples of the nearly complete removal by erosion of remnants of a formerly extensive lava sheet resting on less resistant beds which locally have been left in relief and now appear as buttes or hills owing to the shelter afforded by the hard bed above them. Similar buttes with prominent columns on their summits are well known in the western portion of the United States, and have long been recognized as monuments spared by erosion. This tentative explanation, while based principally on the sketch published by Strachey, and familiarity with similar topographic forms in the region drained by the Columbia River, and occupied by the Columbia River lava—the counterpart in many ways of the Deccan trap of India—is sustained by other considerations, as will appear later in this article.

Professor John C. Branner† has recently invited renewed attention to Fernando de Noronha, an island in the South Atlantic about 230 miles from the northeast coast of Brazil, the summit of which is formed by a conspicuous, irregular tower-like mass of igneous rock, 500 feet high, the inaccessible summit of which rises 1000 feet above the sea. In the article referred to mention is made of the fact that Charles Darwin, in giving an account of his observations while connected with the voyage of the *Beagle* in 1832 to 1836, remarks in reference to the Peak of Fernando de Noronha: "One is inclined to believe that it has been suddenly pushed up in a semi-fluid state." Sketches of the remarkable culminating spire of the island are also presented and its resemblance in form and similarity of position in reference to the elevation on which it stands, to the obelisk of Pelé, pointed out.

Branner states frankly, however, that the resemblance of the Peak to the obelisk of Pelé "may be quite accidental," and in the earlier article mentioned in the preceding footnote presents

*Vol. lxviii, Oct. 15, 1903, pp. 573–574.

†This Journal, December, 1903, Series IV, vol. xvi, pp. 442–444. A detailed account of the geology of Fernando de Noronha, also by Branner, was published in the same Journal, Series III, vol. xxxvii, 1889, pp. 145–161.

evidence tending to show that, as suggested by Darwin, "the Peak is part of a great dike, the only remnants of which now exposed are the upper portions of the Peak itself, and the columns at the Horta do Pico, a short distance to the south-west."

In the case of the buttes of the Deccan trap region of India, and of the Peak of Fernando de Noronha, the suggestions that have been offered in reference to their being of the same type as the obelisk of Pelé, are based almost entirely on similarity of form; but something more than this is evidently required before similarity of origin can be considered as established. In the study of topographic forms of the nature of those in question, it is essential that criteria for their classification should be formulated. An attempt in this direction will be made later in this article, after which the places to be assigned the monumental forms brought to the front by Strachey and Branner will be considered.

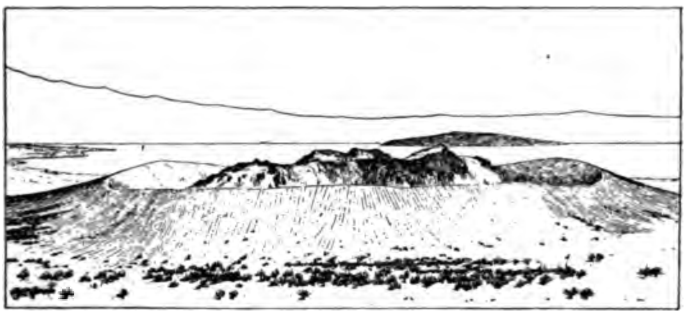


FIG. 1. Panum Crater, Mono Lake, California.
(Reproduced from the Eighth Annual Report of the U. S. Geological Survey.)

It is not necessary to go to India and Brazil, however, to find illustrations of massive-solid volcanic eruptions of the Pelé type, as instructive examples occur among the abundant volcanic records of the United States.

In the case of the extensive group of recent volcanic craters on the east side of Mono Lake, California, there are several examples of the upward protrusion of highly viscous or essentially solid lava which, in at least one instance, rose in a tower-like form to a greater height than the rim of the crater of lapilli which surrounds it. The phenomenon referred to is described as follows in my book entitled "Volcanoes of North America,"* in which the above sketch of Panum crater also appears:

* Israel C. Russell: "Volcanoes of North America." The Macmillan Company, New York, 1897, p. 221. The account of the Mono Craters presented in this book is based on an earlier publication by the same author; namely, "Quaternary History of Mono Valley, California," in the 8th Annual Report of the U. S. Geological Survey, Washington, 1889, pp. 378–386.

"In some cases when an upwelling of lava occurred [in the Mono Craters] it barely entered the bottom of the bowl of lapilli before becoming congealed. The eruption then ceased, so far as that individual vent was concerned. At other times, the thick viscid lava was forced up in the center of the crater until it stood higher than the encircling rim of lapilli, but did not expand laterally. In instances of this nature there is a deep, moat-like depression between the rough and angular protrusion of lava and the smooth inner slope of the encircling crater, in which we may walk entirely around the central tower-like mass. The type of this variety of eruption is furnished by the crater shown in the following illustration [here reproduced] which stands near the shore of Mono Lake, and has been named Panum crater."

The tower-like mass of lava in Panum Crater is not of the nature of a cone of eruption, as is explained in the monograph on Mono Valley referred to above, but a protrusion of angular, massive rhyolitic lava the chemical composition of which is given later in this essay. The lava at the time of its extrusion was so nearly solid that it rose with essentially vertical wall to a height of about 150 feet without exhibiting a tendency to flow in any direction. In the light of the recent example furnished by Pelé, this protrusion of lava may be accepted as being of the nature of a massive-solid eruption, which occurred subsequent to the explosive eruptions that built the sharp-crested encircling crater of lapilli.

The observations pertaining to a peculiar volcanic eruption which occurred in Bering Sea in 1883, during which the shape of Bogosloff Island was greatly altered, are discussed in "Volcanoes of North America," referred to above, and the following conclusion as to its general nature presented:

"Although not personally familiar with Bogosloff, I venture to suggest, from what I have seen in connection with other volcanoes, that the formation of the island was due to the outwelling of viscous lava, which hardened at the surfaces so as to resemble the rough, scoriaceous surfaces so common in lava flows. The lava, being quickly cooled, did not flow as a stream, but as in the case of some of the Mono craters previously described, rose in rugged scoriaceous masses, without much explosive violence. Nothing resembling a crater ring of lapilli and dust is reported as surrounding the elevated crags of lava."

Here again the evidence, interpreted with the aid of the more typical example furnished by Pelé, indicates that a massive-solid eruption occurred. In this instance, the volcanic conduit opened beneath the sea, and the eruption was subaqueous, but a protrusion of essentially solid lava took place, the summit of which rose to a height of 325 feet above the

ocean's surface, and, as is shown by a sketch* made in the fall of 1883, here reproduced, had a tower-like form similar to the obelisk of Pelé.

The rock of which Bogosloff is composed, as determined by G. P. Merrill,† is hornblende-andesite, an analysis of which is presented in the table on page 261 of this essay.

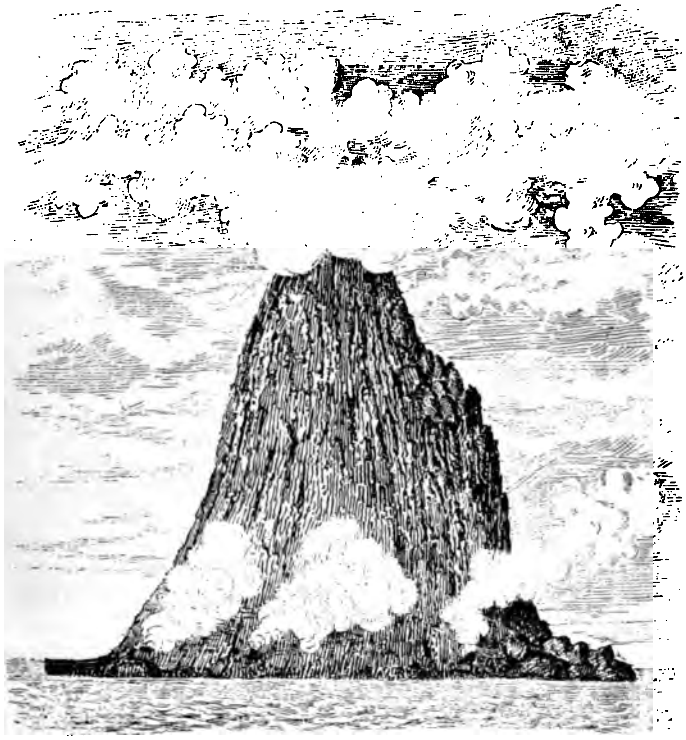


FIG. 2. The New Volcanic Island of Bogosloff, as seen September-October, 1883. After W. H. Dall.

In the case of Bogosloff, there is no evidence on record of a lava flow, or that any of the material extruded was in a fluid or even moderately plastic condition. As will be remembered, no fluid lava was discharged from Panum Crater, and up to the present time during the still continuing period of activity of Pelé only fragmental-solid and massive-solid eruptions have occurred, excepting that highly viscous clots which fell as

* Science, vol. iii, 1884, p. 285.

† Science, vol. iv, 1884, p. 524; also Rocks, Rock-Weathering and Soils, by the same author. The Macmillan Company, New York, 1897, p. 84.

"bread-crust bombs" were thrown out. It is of interest to add to this short list of volcanoes which have erupted material in a massive-solid condition, another example, from which lava was discharged in the three or four ways illustrated by Pelé, and also gave origin to a stream of lava.

The volcano referred to is one of five of modern date (post-Glacial) situated on the east border of Pauline Lake in the south-central part of Oregon, which was visited by the writer during the summer of 1902. A view of the interior of the crater, showing a rough but generally level surface surrounding

FIG. 3. Crater of a volcano near Pauline Lake, Oregon, with massive-solid extrusion in its center.

a central mass of crags, is here presented. The rim of the crater, not appearing in the illustration, is composed mainly of light-colored pumiceous lapilli, and is still intact for about three-fourths of its original circumference, but its northern portion is concealed, or more probably was breached and carried away by a lava flow which was discharged from the crater and went northward for a distance of two miles, and expanded to a width of about one mile. All of the material extruded seems to be andesite, which ranges in physical characteristics from compact, dense, black volcanic glass or obsidian, to yellowish-white pumice so light that it will float on water with the buoyancy of cork. The lava stream has an excessively rough surface, consisting of blocks of obsidian of all sizes up to eight or ten or more feet in diameter with sharp edges and corners, which form irregular piles and ridges in many instances fifty

or more feet high, as well as massive escarpments and smooth fissure-walls of the same material. In many places the glass passes into a highly scoriaceous rock, resembling a coarse black pumice. Along the sides and at the distal end of the lava stream it terminates in precipitous escarpments, exceedingly difficult to climb, from 50 to 80 feet high. The slope down which the lava flowed has a descent by estimate of at least 500 feet to a mile, and the fact that the stream halted on such an incline and cooled with essentially vertical borders, shows that it was excessively viscous at the time it was spread out.

The feature of chief interest in connection with the volcano in question is a tower-like mass of crags of gray stony or granular homogeneous augite-andesite (as determined by F. C. Calkins, of the U. S. Geological Survey), without either obsidian or scoria and in which there is a notable absence of a "flow-structure," which rises to a height of about 250 feet above the crater's floor. The sides of the central mass of crags, as may be judged from the accompanying photograph, are precipitous, and allowing for the blocks that have fallen, must at one time have been nearly vertical. The lava of which the crags are composed is fresh in appearance, there being no discoloration of the surface, and scarcely a lichen has taken root upon it. It exhibits no evidence of there having been a tendency to flow laterally at the time it was upraised, and although irregularly jointed is not columnar.

A peculiar feature of the floor of the crater at the base of the crags described above is that the lapilli, of which it is composed, are in irregular heaps and piles with steep-sided depressions between, the variations in height between the hills and hollows being from 10 to fully 30 feet. The topography of this surface is surprisingly like that of certain glacial moraines, but its roughness is due in part to the occurrence, at a late stage in the activity of the volcano, of many mild steam explosions in the fragmental material of which it is superficially composed, and in part to the formation of fissures in the rocks beneath, which permitted the loose material resting on them to subside irregularly. About the outer margin of the floor of the crater from its eastern around its southern to its northwest portion, there is a belt about 150 feet wide composed of obsidian and black scoria, which resembles the surface of the associated lava flow. This partially encircling belt of large fragments margining the crater's bottom is due to motion which took place after the lava of which it is composed became solid, but whether the motion was of the nature of an underflow in still viscous material beneath a rigid crust, or was an upward movement of the entire lava column within the crater, is uncertain. I am inclined, however, to the latter opinion.

Without attempting to put on record at this time all of the instructive features of the volcano on the border of Pauline Lake, the facts in its history of chief interest in connection with the study of massive-solid eruptions may be briefly enumerated as follows:

The beginning of the eruption was characterized by the occurrence of violent steam explosions, which blew away the highly scoriaceous summit portion of the column of molten material that rose in the conduit of the volcano; the material thus extruded consists mostly of light colored pumice, but mingled with it are sharp-edged flakes of obsidian, and fell about the opening from which it came so as to build a well defined, sharp-crested crater with smooth slopes. The product of these earlier explosions, together with the similar material blown out at about the same time from four associated volcanoes of the same character, was distributed widely over the adjacent mountains. Succeeding the earlier and most violent explosions, came an outwelling of viscous lava which flowed northward down a moderately steep incline, but did not spread widely and was so thick and viscous that it came to rest with nearly vertical borders, the slopes of which have since been reduced by the shattering of the glass of which they are composed, and the fall of the fragments so as to make steep talus aprons. After the discharge of viscous lava, the central portion of the ascending lava column became rigid and was forced upward by pressure from below until it stood, as at present, in massive crags, 250 feet high. Changes of temperature have caused some shattering of the central mass of stony andesite, but not nearly so much as in the case of the surface of the neighboring obsidian lava-flow. Following or accompanying the protrusion of the central crags, renewed but minor explosions occurred about its base, during which the rocks involved were broken and tossed about but not thrown to a great height or widely distributed. Mingled with the angular fragments now occupying the larger portion of the crater and filling it nearly to the level of the part of its encircling rim which remains, there is an occasional volcanic bomb. These bombs have something of the characteristic football shape common among such volcanic products. The examples seen are about eight inches in diameter, and do not show a "bread-crust" or other conspicuous surface features. These masses were projected into the air during explosions in a viscous condition, and received their rudely spherical shapes owing to rotation about their longer axes during their ærial flights. They cooled before striking the ground and were not flattened, and were not sufficiently plastic to adhere to the loose stones on which they fell. Following the period of mild,

superficial explosions came movements which broke the rocks on which rests the irregular surface covering within the crater, and apparently an ascent through a distance of a few feet of nearly its entire mass.

The short list given on the preceding pages, namely, certain of the Mono Craters, Bogosloff, and the nameless crater in Oregon just described, contains all the known or reasonably inferred examples of massive-solid volcanic eruptions in America, which can be referred to the Pelé type.

With the fresh impetus to the study of volcanoes supplied by the remarkable behavior of Pelé, a demand has been made manifest for criteria by means of which the topographic forms produced by massive-solid eruptions can be distinguished from analogous features in the relief of the land. The first step in this direction is the formulation from all available data, aided by reasonable inferences, of a mental conception of the topographic and other characteristics that massive-solid eruptions should present. The facts in hand are sufficient to enable one to make an approximation to such a conception, but the picture will no doubt have to be modified as investigation progresses.

TABLE OF ANALYSES.

Constituents.	No. 1. Rhyolite.* Mono Lake.	No. 2. Hypersthene† Andesite. Monte Pelé.	No. 3. Hornblende Andesite.‡ Bogosloff.	No. 4. Phonolite.§	No. 5. Basalt. Cinder Buttes.‖
SiO_2	74·05%	61·44%	56·07%	58·02%	51·14%
Al_2O_3	13·85	17·27	19·06	20·03	13·95
Fe_2O_3	trace	2·53	5·39	6·18	2·15
FeO		4·18	0·92		12·97
MgO	0·07	2·28	2·12	0·80	2·21
CaO	0·90	6·36	7·70	1·89	6·56
Na_2O	4·60	3·54	4·52	6·35	3·59
K_2O	4·31	1·49	1·24	6·18	2·33
H_2O	2·20	·88	0·99	1·88	·34

* Analysis by T. M. Chatard, U. S. Geological Survey, 8th Annual Report, 1886–87, Pt. I, p. 380.

† Analysis by W. F. Hillebrand, National Geographic Magazine, vol. xiii, July, 1902, p. 291; average of three analyses; minor ingredients as given in original report are not included.

‡ G. P. Merrill, Rocks, Rock-Weathering and Soils, p. 84.

§ G. P. Merrill, Rocks, Rock-Weathering and Soils, p. 80. Average of six analyses given by Zirkel; includes also MnO, 0·58 per cent.

‖ Analysis by W. F. Hillebrand, U. S. Geological Survey, Bull. 199, p. 87: contains also TiO_2 2·41 per cent; ZiO_2 0·12 per cent; MnO 0·44 per cent; BaO 0·25 per cent; P_2O_5 1·59 per cent; Fl 0·10 per cent; FeS_2 (S = 0·08) 0·15 per cent, and traces of V_2O_3; NiO; SrO; and Cl.

One of the first questions to present itself in searching for criteria by means of which massive-solid can be distinguished from other volcanic eruptions, is: Do the lavas extruded in

that condition have any characteristics in their chemical composition which will serve to differentiate them from other lavas? The reply, so far as it can at present be formulated, must evidently be based on the analyses of the rocks known to have been extruded in a massive-solid condition and a comparison of them with the composition of lavas not known to have been erupted in that manner.

In the above table the available analyses of the examples of massive-solid eruptions described on the preceding pages, have been assembled, together with an analysis of a characteristic phonolite (No. 4) to represent the rock of the Peak of Fernando de Noronha, and also an analysis of basalt (No. 5) which is known to have been erupted in a highly fluid condition.

To the examples of massive-solid eruptions cited in the table, should be added an analysis of the augite-andesite of the crater near Pauline Lake, Oregon, described on a previous page, but this data is not available.

As indicated by laboratory experiments made on the fusibility of shales and clays* similar in chemical composition to the rocks enumerated above, the relative fusing points of such rocks may be roughly or qualitatively expressed by the ratio of the silica and alumina to the iron oxides, magnesia, lime, soda and potash, or the "fluxes" present in them. The rule being that for mixtures of the general nature that lavas present, the higher the ratio of the silica and alumina to the fluxes present, the greater the degree of heat necessary to cause fusion, under laboratory conditions. On arranging the analyses given in the above table, so as to indicate the ratio of acid to basic substances given, we have the following:†

TABLE SHOWING RELATIVE FUSIBILITY.

	$SiO_2 + Al_2O_3$.	"Fluxes."	Ratio of $SiO_2 + Al_2O_3$ to "Fluxes."	Approximate temperature of fusion.‡
1. Rhyolite of Mono Craters	87·90%	9·88%	8·8	3100°F.
2. Andesite of Pelé	78·71	19·88	3·9	2520
3. Phonolite	78·05	21·40	3·6	
4. Andesite of Bogosloff...	75·13	21·89	3·4	
5. Basalt of Cinder Buttes.	65·09	29·81	2·2	2250

As indicated by the ratios given in the third column of

* H. Ries, Clays and Shales of Michigan, in Geological Survey of Michigan, vol. viii, Part I, 1900.

† This table is only approximately correct since no account is taken of the water present; and in the case of the numbers 2 and 5, no account is taken of the several minor constituents given in the analyses as originally reported.

‡ According to experiments by C. Barus, quoted in J. D. Dana's Manual of Geology, 4th ed. 1895, p. 273.

the table, the rocks are arranged according to their degree of fusibility; the most refractory being the rhyolite, and the most fusible the basalt. The known massive-solid eruptions 1, 2 and 3 are thus shown to consist of refractory lavas. On the other hand, basalt, which so far as known has not been extruded in a massive-solid condition, is more readily fusible, and in the case of the example cited, as recorded elsewhere,* was poured out in a highly fluid condition. From the data in hand it appears, therefore, that one of the characteristics of the rocks known to occur in massive-solid extrusions is their refractory nature. That this is always a characteristic condition, however, cannot as yet be definitely affirmed. Another related condition is the amount of water-vapor present, since aqueo-igneous fusion is known to require much less heat than dry fusion. The bearing of this principle on the occurrence of massive-solid volcanic eruptions, although seemingly of fundamental importance, cannot be discussed at this time. Assuming, however, that the influence of water-vapor on the fusion of acid and basic lavas is the same, it is evident, from the data given above, that the former should occur more commonly than the latter, in massive-solid extrusions.

In addition to the presence of a plug of rigid lava in the summit portion of a volcanic conduit, in order to bring about a massive-solid extrusion, it is evident that there must also be sufficient pressure on the base of the plug to force it out. Such pressure, as we know, is present during the eruptions of many and we presume all volcanoes which discharge lava. The critical or determining conditions, which lead to massive-solid eruptions, seem to be that the lava in the summit portion of a volcano in action shall become solid. The lavas most apt to solidify at such times are evidently those which are refractory and on cooling pass quickly from a fluid to a rigid condition; that is, the lavas rich in silica and alumina and relatively poor in basic substances. Hence as it seems, it is to be expected that massive-solid extrusions will consist of rocks like the rhyolites, trachytes, andesites and phonolites, rather than basalts or still more basic lavas.

Judging from the heated conditions of the material extruded during a massive-solid eruption at the time it rises into the air, and reasoning also from the known variations in the physical and mineralogical features of igneous rocks which depend on the conditions under which they solidify, we should expect the lavas extruded in a massive-solid condition to present at least three leading physical characteristics: they should be (1) compact, or at most but moderately vesicular, and not scoriaceous, (2) granular or perhaps finely crystalline but not glassy, and

* Israel C. Russell, U. S. Geological Survey. Bulletin No. 199, Washington, 1902, p. 88.

without conspicuous crystals, and (3) irregularly jointed but without a well defined columnar-structure. Each of these propositions may for convenience be considered separately:

1. A compact rather than a scoriaceous condition of the lava forced out during massive-solid eruptions is to be expected from the fact that preceding liquid or fragmental-solid discharges would have removed the more thoroughly vapor-charged summit portion of the rising column, while the material at a greater depth, less thoroughly vapor-charged and congealing under pressure, would form a compact lava. Turning to the known examples of massive-solid eruptions available for comparison, we find this conclusion sustained in the case of the central crags in the Oregon crater described above, which consists of compact granular material.

2. A stony or granular texture, without well defined or conspicuous crystals, would be expected because the lava consolidates with comparative rapidity near the summit of the conduit from which it is later extruded, thus not allowing sufficient time for an advanced stage of crystallization. On the other hand, cooling takes place less rapidly than in the surface portion of a lava sheet, and a glassy texture would not be expected. The rock in question should seemingly be intermediate in structure between those which cool slowly, as in intruded sheets and the central parts of thick lava flows, and those which cool so rapidly that a glass (obsidian) results. Although this reasoning seems to be logical, yet, as is well known, crystals are sometimes formed in deep-seated magmas and are carried to the surface when the containing magmas migrate outward and are discharged by volcanoes. This phase of the problem is obscure, and possibly a granular or crypto-crystalline structure may not be an essential characteristic of lava extruded in a massive-solid condition.

Turning again to the known examples, we find the rock composing the crags in Panum crater, and the one in Oregon described above, to be stony in texture, and in the case of the Oregon crater at least, without either porphyritic crystals on the one hand, or obsidian or pumice on the other.

3. Columnar structure in igneous rocks, as is well known, results from slow cooling, and the columns formed under such conditions have their longer axes at right angles to the cooling surfaces. As the material forced out during massive-solid eruptions is still hot when it reaches the air, and as the diameter of such extruded masses, so far as known, is but a few hundred feet, it is to be expected that cooling would progress too rapidly and too irregularly to permit of the formation of systematically arranged joints, and hence, a well-defined columnar structure would be absent. If in large extrusions the rate of cooling did permit of the origin of a columnar structure, the columns

should be best defined in the central part of the mass, and radiate outward from a central vertical axis toward the sides. The most that could seemingly be expected, however, would be irregular and confused jointing without the formation of a columnar structure. Once more checking deductions by observation, we find no evidence of columnar structure in the massive-solid material extruded from either the Panum crater or the crater near Pauline Lake. As to the other examples cited, information in this connection is lacking.

There is one other feature of volcanic rocks which might reasonably be expected to occur in those forced to the surface in a massive-solid condition, namely, a brecciated structure; that is, the presence of angular fragments of the parent lava, adhering one to another or united by portions of the same magma which consolidated about the fragments produced by the fracturing of the portion which cooled earlier. Such volcanic breccias are common in the lava flow about the Mono craters, and in the similar lava stream near Pauline Lake, but have not been observed in the massive-solid extrusion of those localities. From the manner in which massive-solid eruptions take place, however, it seems as if the conditions would favor the production of brecciated rock of the type just mentioned.

The crucial test of the above deductions will come when the activity of Pelé has decreased sufficiently to permit of a critical study of its obelisk. The prediction may be ventured, however, that it will be found to be composed of massive but somewhat porphyritic rock since the products of the fragmental-solid eruption are of this nature, and without definite columnar structure, although irregular or confused jointing will no doubt be present.

In reference to the topographic forms analogous to those produced by massive-solid eruptions and which might be mistaken for them, there are seemingly but three directions in which uncertainty is likely to arise. These are: (1) the similarity in shape and in location of the crags, spines, obelisks, etc. produced by massive-solid eruptions, and the ordinary *cones of eruption* such as are typically illustrated by the one which forms from time to time within the crater of Vesuvius; (2) the similarity of obelisks, etc. to the tower-like forms produced by the erosion of craters within the conduits of which lava has cooled and hardened, so as to form what are termed *volcanic necks*; and (3) the tower-like forms resulting from the weathering of lava sheets which rest on less resistant and as is most commonly the case, incoherent sedimentary strata, or beds of tuff, and frequently termed *erosion columns.*

1. The necessity of distinguishing between massive-solid eruptions and cones of eruption arises principally from the fact that in fresh and well-characterized examples of each class, an elevation is present within an encircling crater. Cones of erup-

tion, however, in all known instances are composed of highly scoriaceous material, consisting of lava blocks, lapilli, bombs, cakes formed of splashes of liquid lava, dust, etc., and have a tube or conduit within, leading upward to a crater at the top. Such structures are in fact miniature volcanic cones of the same general character as the greater cones in the craters of which they are formed. In all of the characteristics mentioned the differences between cones of eruption and massive-solid extrusions are obvious and need no further discussion.

2. The similarity between volcanic necks exposed by the removal of their enclosing cones, and the tower-like forms produced by massive-solid extrusion, as in the case of Pelé, is most striking. This similarity approximates to identity, inasmuch as a volcanic neck and a volcanic obelisk may be portions of the same lava column; the former being the material within a conduit which cooled in place, or if forced upward did not emerge from its enclosing tube, while the latter represents the summit portion of a congealed lava column that has been forced out of its parent conduit.

Fresh and uneroded obelisks are not to be mistaken for volcanic necks exposed by erosion, because of their freshness and the presence about them of crater walls, or evidence of the destruction of such encircling rims by explosions, or their burial beneath the debris falling from the obelisks themselves, etc. It is in drawing distinctions between much weathered obelisks and volcanic necks when exposed by erosion, that difficulty is likely to arise.

In the case of well-characterized volcanic necks and good although much weathered examples of volcanic obelisks, it seems possible to draw a distinction, although their shapes, positions, etc., are essentially the same. The material forming a volcanic neck cools slowly on account of the insulation afforded by its enclosing cone, and would be expected to form a well crystallized and, in the case of most lavas, a porphyritic rock. Owing to slow cooling, also, the rocks of volcanic necks should exhibit a well defined columnar structure. Such we know to be the case in certain typical examples situated in the northwestern part of New Mexico and having a height of from 800 to 1000 feet above the adjacent plain, concerning which Major C. E. Dutton* writes as follows: "In all of these necks the basalt is columnar. The columns stand or lie in all sorts of attitudes, and in most cases are curved. Frequently they are grouped in radiating *fasciæ*, and at times are flexed and reflexed." The columns are described as varying in size from five or six inches to more than twenty feet across; the larger ones being generally vertical.

* Mount Taylor and the Zuñi Plateau, in Sixth Annual Report of the U. S. Geological Survey, Washington, 1886, p. 172.

Then, too, volcanic necks may contain rocks of any chemical composition ranging from ultra-basic to ultra-acid, that are extruded by volcanoes; while, as already stated, there seem to be good reasons for concluding that massive-solid eruptions occur only in the case of volcanoes which are supplied with highly refractory lavas.

With these considerations in mind, any monumental rock that simulates an obelisk in form, which is composed of basic or, more strictly, easily fusible material, might with greater probability be classed as a volcanic neck, then as a volcanic obelisk. And again, if the material composing such a monument is coarsely crystalline, and traversed by definite systems of joints, producing a well-defined columnar structure, the evidence is seemingly conclusive that it is not of the nature of a volcanic obelisk. In this connection the conditions revealed by the uncovering and erosion of subterranean intrusions, such as dikes, plutonic plugs, laccoliths, etc., need to be borne in mind, but space does not permit of considering them at this time.

Reverting to the case presented by Fernando de Noronha; the topographic form and prominent position of the Peak are such as to simulate in a remarkable way the conditions that may reasonably be supposed to pertain to a weathered obelisk; the rock of which it is composed, as reported by Darwin and Branner, is phonolite, and although, so far as I am aware, no analysis is available of this particular example, phonolites in general have approximately the composition indicated in the table presented above, and are to be included among the igneous rocks of medium fusibility. The rocks associated with the phonolite which forms the Peak of Fernando de Noronha and other neighboring elevations, as stated by Branner,* are of a basaltic type and compose the greater part of the island. From this same authority also, we learn that the phonolite of the Peak is conspicuously columnar; "The direction of the columns varies in some cases as much as fifty degrees. The lowest rocks of the Peak exposed in place are the irregular columns upon the eastern side. The columns are here very nearly vertical; but higher up, even upon this side, they twist and bend to the northeast and thus form the overhanging projection which is so remarkable a feature of this great rock. . . . . . On its western side the columns stand at various angles with the meridian, and usually at a high angle with the horizon." A comparison of this description with that of the columnar structure of the volcanic necks of New Mexico, quoted above, is highly suggestive.

It thus appears that the facts recorded concerning the Peak of Fernando de Noronha do not furnish positive evidence as to its mode of origin. Its shape and prominent topographic position are similar to those of the obelisk of Pelé, but on the

* This Journal, III, vol. xxxvii, 1889, p. 150.

other hand, correspond fully as well with the similar features of many volcanic necks. The chemical composition of the rock of which the Peak is composed, so far as suggestive of its degree of fusibility, is similar to that of the material erupted by Pelé; and so far as this fact has weight, it is evidently not opposed to the idea that the rock in question was extruded in a massive-solid condition. The well-defined columnar structure of the Peak, however, is so similar to that of many volcanic necks and still more numerous igneous dikes, and is so unlike the jointing observed in at least two examples of massive-solid extrusions, and so unlike, also, as we seem justified in assuming, the jointing to be expected in all such extrusions, that it favors the conclusion of its being a volcanic neck or a portion of an igneous dike, rather than of the nature of the obelisk of Pelé.

In reference to the criteria by means of which a distinction can be drawn between residual masses of lava sheets left as columns on the tops of hills or buttes, and obelisks of the Pelé type, but little need be said, since even a cursory examination of such monuments of erosion is usually sufficient to reveal their history. Erosion columns may be composed of any variety of volcanic rock, but as is well known, are most commonly basaltic, are usually vertically jointed and frequently conspicuously columnar, and rest on soft or incoherent material. In most instances, also, in regions where one such residual column occurs, others of similar nature are apt to be present, as well as flat-topped mesas and even broad table-lands. Thus in the nature of the material of which the columns referred to are composed, and in their structure and associations, they differ widely from massive-solid extrusions.

It is at present impracticable to apply the above mentioned criteria to the columns in the Deccan trap regions of India, referred to by Strachey, except so far as topography and the general nature of the rock are concerned. Topographically the columns represented in the sketch mentioned on an early page of this essay, seem to agree much more nearly with erosion columns than with volcanic obelisks, a view which is sustained by the presence of two examples near each other. The Deccan trap is composed of basaltic rock, such as is common in erosion columns and not as yet known to occur in volcanic obelisks. The evidence seems, therefore, to indicate that the columns in question are residual masses left by the nearly complete erosion of a formerly widely extended sheet of lava.

From the considerations presented in this essay, it will be seen that the recent eruptions on Martinique have made important contributions to both geology and geography. In the investigation of volcanoes geological and topographical studies go hand in hand and mutually assist each other.

Art. XXIV.—*On a New Nepheline Rock from the Province of Ontario, Canada;* by Frank D. Adams.

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In a paper which appeared in this Journal some years since,* the discovery of a large body of nepheline syenite in the township of Dungannon, in eastern Ontario about 85 miles northwest of Kingston, was recorded. As stated at the time, this occurrence is of large dimensions and the rock constituting it is in many respects remarkable in character. The discovery was one of the first results of a geological survey of this part of Ontario—at that time, geologically speaking, a *terra incognita*—which had just been undertaken by the writer for the Geological Survey of Canada. As the survey was continued during several succeeding summers, many additional occurrences of nepheline syenite were discovered and mapped, and as the result of more extended study the area is now known to present one of the most extensive and interesting developments of nepheline-bearing rocks which are known to occur anywhere. The geological maps of the area in question, by Dr. Barlow and the writer, are now completed and are being engraved, and it is expected that they, with the accompanying report, will be ready for distribution shortly. During the progress of the survey, Prof. Miller and Dr. Coleman of the Ontario Bureau of Mines visited the district and described certain of the occurrences of the nepheline syenite in papers published in the Reports of the Bureau and elsewhere.

When engaged in elaborating their Quantitative System for the Classification of Igneous Rocks, Messrs. Iddings, Cross, Pirsson, and Washington found that certain subdivisions of their scheme had no representatives amongst the rocks hitherto described. One of these subdivisions was Order 8 of the Peralkalic Persalanes, to which would belong nepheline syenites very poor in feldspar and very rich in nepheline, with perhaps allied varieties of related rocks. As it has been mentioned in the paper on the Dungannon nepheline syenite, that in that district rocks composed almost exclusively of nepheline occurred, the authors of the Quantitative Classification suggested that this order might be called Ontarare. No analysis, however, of any of these rocks had then been made, so that their precise composition remained somewhat doubtful. The name Ontarare, however, was given to the order, the present writer undertaking to make good the claim of the Province to the bestowal of the name, by describing an Ontarare from the district in

* F. D. Adams: On the Occurrence of a Large Area of Nepheline Syenite in the Township of Dungannon, Ontario, this Journal, July, 1894.

question which would serve as a type for the order. It is the purpose of the present paper to make good this undertaking by describing the first Ontarare.

The nepheline syenites of eastern Ontario, while always presenting the same general character, are represented by many varieties. The rock is usually coarse in texture, while in some of its pegmatitic developments the most extraordinary size of grain is attained. In one occurrence near the village of Gooderham in the township of Glamorgan, consisting of nepheline, albite, and an occasional individual of lepidomelane, the nepheline masses—for the most part single individuals—are often as much as three feet in diameter; while in several other occurrences nepheline syenite pegmatites of almost equal coarseness of grain have been found. The rock, furthermore, differs from that of most nepheline syenite occurrences, in that it commonly presents a more or less distinct foliation or gneissic structure, which foliation is not due to crushing *in situ* with the development of cataclastic structure, but is produced by a parallel arrangement of the constituent minerals, which arrangement seems to be a primary one or is at least unaccompanied by pressure phenomena.

The nepheline syenites of the region, furthermore, show a wide variation in mineralogical composition, several varieties often occurring together in the same mass, forming rude bands which coincide in direction with the foliation, thus serving to accentuate this and render it more pronounced.

The iron-magnesia constituent which is most commonly present is hornblende, represented by alkali-rich varieties, of which hastingsite may be taken as a type.* Pyroxene, however, replaces this in some cases and biotite in others. In some places these minerals preponderate over the colorless constituents of the rock and in these varieties garnet locally occurs in considerable amount. These dark bands, or schlieren, are, however, not very common and the prevailing facies of the rock is one which is light in color owing to the abundance of feldspar and nepheline. In certain occurrences other minerals which usually play the part of accessory constituents—such as corundum, sodalite, and cancrinite—attain more prominence, the first mentioned mineral now being very extensively mined in an occurrence of the syenite, near Combermere; while some of the largest masses of sodalite† which have ever been found are those which have been obtained from the nepheline syenite in

* F. D. Adams and B. J. Harrington: On a New Alkali Hornblende and a Titaniferous Andradite from the Nepheline Syenite of Dungannon, Ontario, this Journal, March, 1896.

† B. J. Harrington: On Nepheline, Sodalite and Orthoclase from the Nepheline Syenites of Dungannon, Hastings Co., Ontario, this Journal, July, 1894.

the township of Dungannon, to the east of the village of Bancroft.

These nepheline syenites occur cutting the rocks of the Grenville series, which consist largely in this district of crystalline limestones. Their wall rock consequently in almost every case is limestone. The only occurrence which is not directly associated with large masses of this rock is a large isolated intrusion in the township of Methuen, where the country rock is granite and amphibolite, the latter holding only a few small limestone bands.

With this is connected one of the most curious phenomena presented by these nepheline syenites, namely, the presence in them almost everywhere of calcite. This calcite when appearing in the analysis of a rock at once suggests an advanced stage of alteration, since calcite when found in igneous rocks is almost invariably a secondary product. In other cases calcite in plutonic rocks has been supposed to occupy miarolitic druses and to have been deposited in these by percolating waters.

A very careful examination, however, of the calcite-bearing occurrences of nepheline syenite in the various parts of this area has clearly shown that in the case of these rocks the calcite represents inclusions of the crystalline limestone penetrated by the intrusion, a fact which receives additional substantiation in the fact that in the Methuen occurrence, when the wall rock is not limestone, the nepheline syenite does not contain calcite. Along the borders of the intrusion, the nepheline syenite is seen to eat into the limestone and to enclose large masses, the constituent minerals of the syenite growing into the substance of the limestone, often with well defined crystal terminations. These masses often show a coarsening in grain as a result of the metamorphic action of the intruding rock. On receding from the contact, the inclusions become less numerous and smaller, and eventually the large masses are disintegrated into separate individuals of calcite or small groups of calcite grains. These, under the microscope, can be seen as rounded, often perfectly round, inclusions completely enclosed in a single individual of nepheline or other constituent of the nepheline syenite, or lying between other constituents of the rock, which latter can be seen to have grown into the calcite. In these cases all the minerals are perfectly fresh and unaltered, and, while the constituent minerals of the nepheline syenite rarely show pressure phenomena, the calcite individuals are often seen to be much bent and twisted and to display marked strain shadows, the movements displayed being those which overtook the limestone before the intrusion of the syenite into it.

It being, therefore, clearly recognized that the calcite is some-

thing foreign to the original magma and that it merely exists in the rock in the form of inclusions, in calculating out the mineral composition of the rock the calcite is set aside and the primary magma regarded as having the composition of the calcite-free rock. The nepheline syenite of the island of Alnö,* it may be mentioned, is characterized by the presence of calcite which is not of secondary origin, whose mode of occurrence in many respects is very similar to that of the calcite found in the nepheline syenite of Ontario.

Seven typical varieties of the rock have been analyzed and these serve to show the range in composition displayed by the magma. Of these, three were found to belong to the class of the Persalanes and to the sub-class Pesalone; using the nomenclature recently proposed by Messrs. Cross, Iddings, Pirsson and Washington,† while three others belong to the class Dosalane and the sub-class Dosalone. One is a Phlegrose, one a Vulturose and one a Miaskose, while two are referable to Essexose and one is a Kallerudose. These will be fully described in the forthcoming Report to which reference has already been made.

In addition to these there is the rock described in the present paper. This is a variety of the nepheline syenite which is almost free from feldspar and which consists essentially of nepheline and the iron-magnesia constituent, in this case hornblende. It occurs in the township of Monmouth, about 25 miles west of the township of Dungannon. Here, on lots 9, 10, 11 and 12 of ranges VII to VIII, a mass of nepheline syenite breaks up through a great band of crystalline limestone. The southern limit of this mass is unfortunately mantled by drift, so that its extension in this direction is somewhat uncertain. It has, however, the form of a flattened ellipse, the longer diameter measuring one mile and the shorter diameter about half a mile, and is completely surrounded by the limestone. The mass holds many inclusions of the limestone through whose shattered mass it penetrates. These included limestones frequently are coarsely crystalline and are more or less impure from the presence of secondary silicates developed by the contact action. These masses have the appearance of being in process of replacement by the intruded magma. The nepheline syenite in some places along its contact with the limestone is rich in hornblende, but elsewhere along the border it contains but a very small proportion of the dark constituent, so that no distinct endomorphic action can be traced to the influence of limestone. In some few places, however, near the limestone

* Hogbom, A. G.: Ueber das Nephelinsyenitgebiet auf der Insel Alno. Geol. Fören. i. Stockholm Förh., Häft. 2, 1895, p. 140.

† Quantitative Classification of Igneous Rocks, University of Chicago Press, Chicago, 1903.

the syenite holds scapolite. Taking the intrusion as a whole it may be said to consist essentially of albite, nepheline and hornblende, but as is so frequently the case in this region it shows a wide variation in relative proportion of the constituents in different places. In some places it is rich in feldspar, while elsewhere the nepheline almost entirely replaces this mineral. In the latter case the nepheline is usually associated with a considerable amount of hornblende, in addition to which in many cases a small amount of red garnet is present.

The feldspathic and feldspar-free varieties run in rudely parallel bands or schlieren. These are often several feet in width and may be traced for several hundred yards along the strike of the banding. They represent distinct magmas resulting from extreme differentiation. The rock here described was collected from one of the bands six feet in width and several hundred yards long.

The rock is coarse in grain and consists essentially of white nepheline and black hornblende, the former preponderating largely. It thus has a rather striking appearance on the fresh fracture. On the weathered surface the contrast presented by the two minerals is less striking, as the nepheline assumes a pale gray color. Under the influence of the weather, the nepheline, as is always the case with these rocks in this district, presents the appearance of having been dissolved away, the weathered surface being smooth and recessed, the hornblende and the accessory feldspar and cancrinite of the rock standing out from the surface of the nepheline.

Under the microscope the rock is seen to consist essentially of nepheline and hornblende, with plagioclase, cancrinite, and calcite as accessory constituents, as well as sodalite, apatite, sphene, biotite, pyrite and iron ores, these latter minerals being present in extremely small amounts.

The Nepheline occurs in large well-defined grains, presenting the usual characters displayed by the species. It is clear and fresh.

The Hornblende is green in color, the pleochroism and absorption being as follows: $\mathfrak{a}=$ pale greenish yellow. $\mathfrak{b}$ and $\mathfrak{c}=$ very deep green. The absorption is $\mathfrak{c}=\mathfrak{b}>\mathfrak{a}$. The maximum extinction observed in the sections of the rock was 19°. It is an alkali hornblende, containing less iron than hastingsite, but, like it, as shown by the calculation of the analysis of the rock, belonging to the division of the Syntagmatites.

The Plagioclase is present only in very small amount and is in some cases untwinned, while in other cases it shows a faint, polysynthetic twinning. In thin sections it bears a very close resemblance to the nepheline, and when untwinned it is difficult in all cases to distinguish the two minerals. When a sec-

tion is treated with acid and etched, however, the plagioclase is seen to occur in individuals of a more or less rounded form or with curving outlines, lying between the nepheline grains or enclosed in the latter. The feldspar isolated from another variety of the rock in the same occurrence was found to be albite, and this feldspar has, therefore, been taken as albite in calculating the Mode of the rock.

The amount of Cancrinite present varies very considerably in different specimens of the rock. In the specimen analyzed about 5 per cent was found. In other specimens more is found, although in no case is it very abundant. It is clear and colorless, but is at once distinguished from the nepheline when examined between crossed nicols by its much higher polarization colors, which in thin sections frequently rise to a blue of the second order. It is clear and free from interpositions and in convergent light is seen to be uniaxial and negative. It also shows a slight but distinct dispersion of the bisectrices, giving a brownish and a bluish tint on either side of the position of maximum extinction. When separated by Thoulet's solution, the mineral was found to have a specific gravity between 2·48 and 2·44, and to be readily decomposed when heated with dilute hydrochloric acid with the evolution of carbonic dioxide and with subsequent gelatinization. The cancrinite occurs in the nepheline in the form of narrow strings or more rarely in little bunches of grains. These usually follow the course of minute cracks or cleavage lines, but also are frequently seen to follow the boundaries of individual grains of nepheline on their contact with grains of other minerals. Thus between crossed nicols they appear as a brilliant edging about hornblende individuals or about calcite inclusions in the nepheline, the small prismatic individuals of cancrinite being arranged with their longer axes at right angles to the contact or to the course of the crack, as the case may be. The cancrinite has the appearance of being an alteration product of the nepheline.

The Calcite occurs in large single individuals, which are found as inclusions in both the hornblende and the nepheline. The single individuals are often perfectly circular in outline, and the enclosing mineral is perfectly fresh and unaltered and is sharply defined against them. In other cases the same large calcite individuals lie between the other constituents of the rock, in all cases having the character of inclusions. They generally show very marked strain shadows, while the other constituents show but little or no evidence of pressure phenomena.

The Apatite is found as occasional more or less rounded individuals, enclosed in the nepheline or hornblende, but, like the other accessory constituents, merits no especial description.

An analysis of the rock made for me by Mr. M. F. Connor gave the following results:

SiO_2	39·74
TiO_2	·13
Al_2O_3	30·59
Fe_2O_3	·44
FeO	2·19
MnO	·03
CaO	5·75
MgO	·60
K_2O	3·88
Na_2O	13·25
CO_2	2·17
SO_3	trace
Cl	·02
S	·07
H_2O	1·00
	99·86

If, following the methods of the Quantitative Classification, the Norm of the rock be calculated, that is to say the proportion of standard minerals which would give a magma of this composition, or in the form of which the rock under other conditions of cooling might have solidified, this is found to be as follows:

Anorthite	12·51
Nepheline	67·72
Leucite	8·28
Olivine	3·70
Akermanite	·40
Magnetite	·70
Ilmenite	·30
Pyrite	·14
Calcite	4·92
	98·67
Water	1·00
	99·67

This gives the rock the following position in the Quantitative Classification:

Class 1—Persalane.
Order 8—Ontarare.
Rang 2—(Domalkalic).
Sub-rang 4—(Dosodic).

As this is the first Ontarare which has been described, the rangs and sub-rangs have received no names as yet. It is proposed, therefore, to call rang 2, Monmouthase, and sub-rang 4, Monmouthose, from the township of Monmouth in which this rock is found, while, as an ordinary designation, the name Monmouthite may be applied.

The Mode, or actual mineralogical composition of the rock, is quite different from the Norm, as given above, no leucite, anorthite, olivine, or akermanite being actually present. The mode is *abnormative** to a striking degree.

The Mode is as follows:

Albite	1·83
Nepheline	72·20
Sodalite	·28
Cancrinite	5·14
Hornblende	15·09
Hematite	·50
Calcite	3·12
Pyrite	·14
	98·30
Water	·50
Excess of Al_2O_3	1·20
	100·00

In calculating this mode the nepheline is taken as consisting of soda nepheline and kaliophyllite, in the proportions of 5 to 1, which is the composition of the nepheline of the nepheline syenite occurring further to the west in the area of the township of Dungannon.† One-half of the water found in the analysis is considered as being present in the cancrinite, the remainder being regarded as belonging in part to the hornblende and as existing in part as hygroscopic water. This gives cancrinite in about the proportion in which it seems to be present in the thin sections of the specimens analyzed.

The various bases not required by the other minerals and remaining over to form the hornblende, are present in the proportions required to form syntagmatite; which are the proportions in which these bases are found in the hastingsite of the Dungannon nepheline syenite. The hornblende has accordingly been calculated as syntagmatite, using the theoretical values given by Zirkel: Lehrbuch der Petrographie, vol. i, p. 303. This accounts for the existing percentages of all the constituents of the rock, with the exception of an excess of 1·20 per cent of alumina.

Of the rocks hitherto described, those which bear the closest resemblance to Monmouthite are the Urtites of the Peninsula of Kola.‡ These, however, belong to the class of the Dosalanes.

Geological Department, McGill University, Montreal, P. Q.

* See Quantitative Classification (loc. cit.), p. 150.

† B. J. Harrington: loc. cit.

‡ W. Ramsay: Das Nephelinsyenitgebiet auf der Halbinsel Kola, Fennia. 15, No. 2, p. 22.

ART. XXV.—*Note on a Calcite-Prehnite Cement Rock in the Tuff of the Holyoke Range*; by B. K. EMERSON.

AT Lymans Crossing, now abandoned, a mile north of Smiths Ferry, and just south of the river notch through the Holyoke Range, is a large cutting through the posterior trap sheet, exposing the upper surface and the superjacent tuff beds. The cementing material which holds the tuff fragments together at the base of the bed is quite peculiar. It looks like a felsite or a compact sedimentary limestone. It is clear gray with faint shade of green.

The small angular fragments of trap enclosed in this cement are often one to three inches apart, showing that it cannot be a simple secondary interstitial cement produced by a later infiltration. It contains here and there rounded or pear-shaped cavities, filled with coarse calcite, which seem to be certainly steam holes. Minute scales of graphite just visible to the eye are quite generally distributed and are slightly larger and more abundant where the cement rock borders against the trap. The scales are graphite and not molybdenite, since they float in Thoulet's solution.

Under the microscope the trap fragments are seen to be normal and to preserve their usual characters up to their borders.

The cement rock has a confused crystalline texture and large stationary black crosses appear everywhere over the surface. It is made up in about equal parts of calcite in shapeless areas with very irregular boundaries, and a colorless prehnite in coarse rudely radiating prisms and wheel-shaped forms which plainly cause the black crosses. A few blades of a pale brown biotite are present but may be secondary. Distinctly secondary are the angular fragments of acid plagioclase and microcline, which have a granitic aspect. The rock has sp. gr. = 2·86, which indicates that a little more than half its mass is prehnite, and the study of the section confirms this. The small crumpled graphite scales are also secondary, and must have come from west of the axis of the Green Mountains, twenty-five miles west, or from the Brinefield rusty schist area fifteen miles east. The brightly shining scales resemble those from the western area. The same graphite is found extensively in the adjoining sandstone. There is also a small amount of a primary albite deposited by the same waters from which the prehnite crystallized and having the same undulose extinction which characterizes the albites deposited by heated waters in the cavities in the trap.

The outburst of the tuff followed immediately on the outflow of the trap sheet and many of the scoriaceous bombs which first fell sank quite deeply into the latter and can be seen enclosed in compact trap as at the western pavilion in Mountain Park.

The cement rock formed at the base of the tuff in waters which were slightly contaminated by the materials of the sandstone, the graphite scales being especially far travelled because of their indestructibility and lightness. It increased to very considerable thickness between the trap fragments and crystallized so rapidly and in such high temperature that it enclosed pear-shaped steam holes like a scoria. After the temperature had fallen below the solution point of prehnite, these cavities were filled by calcite.

Amherst College, Mass.

ART. XXVI.—*The Developmental Changes in some Common Devonian Brachiopods;* by PERCY E. RAYMOND. (With Plates XII–XVIII.)

INTRODUCTION.

CERTAIN layers of impure, clayey limestone from the Moscow (Hamilton) shales which occur in a ravine near Canandaigua Lake, N. Y., were found by Dr. John M. Clarke to contain fossils whose shells had been so completely replaced by silica that when the rock was etched in acid the shells were left in as perfect condition as when they were buried in the limy clay of their native sea-bottom. A large quantity of this material was obtained by Prof. C. E. Beecher, and through his kindness part of it has been placed at the disposal of the writer for study. About 65 pounds of the rock were treated with hydrochloric acid, and the shells washed from the clay which remained after the calcium carbonate had been removed. From this material about 15,000 nearly perfect specimens have been selected, while a much greater quantity of fragmentary material was discarded. Nearly all classes of invertebrate animals are represented in this collection, but the brachiopods are most numerous, comprising two-thirds of the total number of individuals, and furnishing at least thirty-five hundred specimens of a single species (*Chonetes scitulus*). Next in abundance to the brachiopods are the Bryozoa, then the Crustacea, worm tubes, pelecypods, gastropods, corals, and cephalopods, in the order named. The echinoderms are represented only by crinoid columns and the sponges by a few spicules. A few fish scales were also found. Chitinous shells of the *Lingula* type do not appear to have been preserved, and some of the Dimyarian bivalves occur only as casts.

The majority of shells are white, but some are dark gray to black, while the trilobite tests are light to dark brown. The color seems to be fairly uniform for all the individuals of the same species. For instance, there are two species of *Monotrypa*, and all the individuals of both species are black, yet most of the Bryozoa are light colored. In the case of *Chonetes mucronatus*, however, while most of the specimens are dark, a few are white.

The state of preservation of the fossils in this material is remarkable, even the finest details being retained, which shows conclusively that the shells were not subjected to any rough wave action after the death of the animal. The graceful fronds of the Fenestellidæ are obtained as they grew, and the delicate spines of the Productidæ and the spiniform exten-

sions of the cardinal angles of the young *Stropheodonta* are in perfect condition. Unfortunately the brachial loops and spires are not so well preserved, though many specimens of *Eunella* show a large part of the loop, and in one young form it is entire. Many specimens of *Tropidoleptus* retain the delicate median septum and the crura, but the loop was not observed.

Perfect examples of the little ostracods of the genera *Halliella* and *Kirkbya*, whose shells are merely a fine network, were obtained, as well as many of the *Rhombopora*-like Bryozoa, covered with minute spinules. The pelecypods, which are nearly all immature individuals, are excellently preserved, and many of them retain the prodissoconch.

The advantage of this method of collecting is shown by the great number of specimens of supposedly rare species obtained. *Pholidops hamiltoniæ*, which is rare in ordinary collections, is extremely abundant in this material, only one species being more common. *Pholidops oblata*, of which not more than a dozen specimens have been found in other localities, has here been obtained by the hundreds, while *Ascodictyon stellatum*, *Autodetus Lindstrœmi*, and the ostracods, which are seldom found in any quantity, are very common. The whole fauna consists of about 125 species, 115 of which have been thus far identified, there being 10 or 12 whose specific identity is uncertain, and some of these are probably new. The fauna is distributed as follows:—Crustacea: Trilobita, 5 species; Ostracoda, 11; Cephalopoda, 1; Gastropoda, 8; Pteropoda, 3; Pelecypoda, 16; Brachiopoda, 39; Bryozoa, 18; Vermes, 6; Anthozoa, 5.

A large proportion of the individuals of the Brachiopoda are in immature stages, many of them being less than 1^{mm} in length. From that size there are specimens showing all gradations up to the adult, and, in many cases, to senile stages. Series representing all these stages have been selected wherever possible, and carefully studied, in order to ascertain what changes took place in the shell during the lives of the individuals of the various species.

The pioneer work of this sort was done by Beecher and Clarke on material obtained from Waldron, Indiana. In the memoir published by them giving the results of this work, the developmental stages of 25 species, belonging to 18 genera, were described. Later work by Beecher, Schuchert, and Cumings, has added full descriptions of several more. Among the fossil brachiopods, 2 genera of the Rhynchonellidæ, 3 of the Atrypidæ, 1 of the Craniidæ, 1 of the Eichwaldiidæ, 4 of the Strophomenidæ, 4 of the Orthidæ, and 1 of the Porambonitidæ, have been studied in this way up to the present time.

From the present material the writer has been enabled to study the complete series of changes in 20 other species, and a partial series in 4 more. This list comprises 15 genera, 11 of which are not represented in the work previously done. These genera belong to the families Centronellidæ (*Trigeria*), Terebratulidæ (*Eunella*), Terebratellidæ (*Tropidoleptus*), Spiriferidæ (*Cyrtina*, *Delthyris*), Craniidæ (*Pholidops*, *Craniella*), Strophomenidæ (*Stropheodonta*, *Pholidostrophia*), and Productidæ (*Chonetes*, *Strophalosia*). *Crania*, *Rhipidomella*, *Spirifer*, and *Orthothetes* are here represented by Devonian species, while the previous work has been done on those from the Silurian; interesting points may be therefore obtained by comparing results.

The present paper is an abstract of the results attained from this study, and gives a summary of the most interesting facts ascertained in regard to 17 of these species.

Crania crenistriata Hall.

Pal. N. Y., iv, 1867, p. 28, pl. 3, figs. 13–16.

The smallest specimen of this species is 2·66^{mm} long and 3·33^{mm} wide. At the apex it shows the nepionic shell, which is similar in form to the adult, but non-plicate. It is 1·46^{mm} long by 1·66^{mm} wide. In this species, and in *Craniella hamiltoniæ*, the young shells have, as a rule, more conical dorsal valves than the adults.

Stropheodonta inæquistriata Conrad.

(Plate XIII, Rows 2, 3, and 4.)

Pal. N. Y., iv, 1867, p. 93, pl. 12, figs. 6–8.

Nepionic Stage.—In the nepionic stage the shell of this species is oval in outline, and wider than long. Both valves are convex, though in some specimens the dorsal valve becomes flat in front. The latter valve bears a narrow median fold which extends about half-way to the front. Otherwise the shell is smooth. The length of the average specimen in this stage is ·42^{mm} and the width ·54^{mm}.

Changes during Development: Outline.—Immediately after the nepionic stage the width at the hinge becomes greater than that below, and remains so through all succeeding stages. The cardinal extremities are most alate during the adolescent period, and all immature forms are characterized, when perfect, by long hinge lines. In the senile state, the cardinal angles are not so extended, but the width at the hinge is still the greatest width. (Compare the young specimens, Nos. 14 and 15 of the series, with the adult and senile individuals on Plate XIII, Row 4.)

Convexity of Valves.—In the nepionic stage both valves are convex, but, when a length of about ·5mm is reached, the dorsal valve becomes concave in front and follows very closely the curvature of the other valve throughout succeeding stages. Shells from 1 to 6mm long are very slightly convex, sometimes almost flat, but, as they grow older, the convexity increases until in the gerontic stage they are almost hemispherical.

Muscle Scars.—The migration of the muscles in this species during the life history is most interesting. The normal form of the scars in the ventral valve of the adult is shown in Paleontology of New York, Vol. 4, Plate 15, figure 10, and figure 2h, Plate 18, gives the interior of a dorsal valve at the same stage. Figure 2h, Plate 18, and figure 11, Plate 15, show the ventral and dorsal valves of a senile individual.

In the smallest ventral valve in which the muscles have left distinguishable impressions (4×4^{mm}) the diductors have oval, somewhat widely separated scars, between which are the two small adductors, one on either side of the median line. The diductors are bounded posteriorly by two ridges making a wide angle with each other. The adductor scars have faint ridges on either side and another ridge between them. In a little later stage these three ridges become sharp and distinct. The median one runs nearly to the beak, while the others remain short, sharp, and rather high, curving outward. In the later neanic stages these ridges arch over and join the ridges which bound the diductors.

The two ridges bounding the posterior borders of the diductors send off processes a short distance in front of the hinge, which turn inward and run parallel for a little way. They rise sharply from the floor of the valve, and overhang on the side toward the median line. In the later neanic stages the whole extent of the diductor impressions is bounded by a low, sharp ridge that is later resorbed.

During the adult stage the parallel portions of the two ridges which bound the diductors are extended and strengthened, and the divergent portions resorbed. The median ridge becomes stronger and rounded, and the two sharp ridges which separated the adductors from the diductors disappear. An almost square muscle scar is thus produced, which has less area for attachment of the muscle, but is better located for a direct pull on the cardinal process.

In the dorsal valve the two pairs of adductors occupy a small space in front of the cardinal process, and are usually bounded by a low ridge. The outer pair, the posterior adductors, make up most of the scar. They are small, roughly triangular, and situated close to the front of the cardinal process. The anteriors are narrow, and are situated on a platform between, and

slightly above, the level of the posteriors. Between the scars, on the median line, is a low, short septum which is hardly elevated above the surface of the shell in young specimens, but becomes prominent in adults. On either side of it is a low ridge extending back nearly to the base of the cardinal process. In the adult the portion of these ridges in front of the muscle scars becomes high and incurved, and may function as a support for the brachia. These ridges are short, and their anterior ends are not half-way to the front of the valve. They appear to be homologous with similar ridges in *Chonetes scitulus*, which are certainly connected with the brachia. The structure of the muscle scars and ridges in this species should be compared with that in the dorsal valve of *S. concava*. In neither case do the ridges in front of the muscle scars function as the attachment for muscles, as has been suggested by many writers.

Hinge Structure.—A few of the smaller specimens show a short exsert pedicle tube. In adult and senile stages the pedicle opening is pushed back onto the beak, and is very minute.

Stropheodonta perplana Conrad.

(PLATE XIII, ROW 1.)

Pal. N. Y., iv, 1867, pp. 92, 98. pl. 11, fig. 22; pl. 12, figs. 13-15.

Protegulum.—The protegulum of this species is nearly circular, biconvex, with arcuate hinge. It measures $\cdot 10 \times \cdot 10^{mm}$ on one specimen, and $\cdot 12 \times \cdot 12^{mm}$ on another.

Nepionic Stage.—The shell in the nepionic stage is convex in both valves, nearly as long as wide, and both valves are smooth. On the dorsal valve is a fold which extends nearly to the front of the shell (figure 1).

Changes during Development.—Like *S. inæquistriata*, this shell becomes strongly alate in the neanic stages and the hinge width remains the greatest width throughout life. (See specimens 4, 7, 10, and 14 of the series, for examples of this.) After the nepionic stage, the dorsal valve becomes first flat and then slightly concave. The shell remains nearly flat throughout all stages.

1

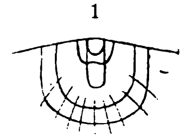

FIGURE 1.—*Stropheodonta perplana* Conrad; dorsal valve, showing shell in nepionic stage, the fold, and the origin of the striæ. ×16.

Muscle Scars.—In this species there is no change in the position of the muscle impressions during life. The adductor scars in the ventral valve are divided by a diagonal line into anterior and posterior elements, a fact not shown in calcified specimens.

Pholidostrophia iowaensis Owen.

Pal. N. Y., iv, 1867, p. 104, pl. 18, fig. 1.

Changes during Development.—This shell, like the other Stropheodontas, becomes strongly alate in the neanic stages, but the principal change during its development takes place in the adult and early senile stages, when the shell which has formerly been nearly flat is abruptly deflected in front, making the ventral valve very convex in this part, while the dorsal is correspondingly concave. The exterior is smooth in all stages. A single specimen from Eighteen Mile Creek shows a few distant radiating striæ, which may be taken as suggestive of an ancestral character.

2

FIGURE 2.—*Pholidostrophia iowaensis* Owen; brachial valves, showing muscle scars and brachial ridges. Natural size.

Brachial Markings.—In front of the muscle scars of the brachial valve, there is, on each side of the strong median septum, a crescent-shaped ridge, which turns in rather abruptly as a sort of hook at the anterior end (figure 2). In adults these processes extend about two-thirds the distance to the front of the shell. In the young, they extend somewhat further forward and are more divergent. These ridges correspond, in position, with the brachial ridges of *Chonetes* and *Productus* and probably should be correlated with those markings. They have been given considerable taxonomic importance by some authors, the group of Stropheodontas which bears them being considered by Œhlert as forming a transition group connecting the Strophomenidæ and the Productidæ. It is probable, however, that the occurrence of these markings is due more to the age of the individual shell than to anything else, for with increase in the deposit of testaceous matter the brachial scars become more distinct in those species in which they are usually observed, and these scars are not confined to the Devonian Stropheodontas but can be seen in *Rafinesquina* from as old a formation as the Chazy; they are likewise well known to occur in *R. Jukesii* and *Stropheodonta profunda.**

The genus *Pholidostrophia* was suggested by Hall and Clarke to include a section of the Stropheodontas in which the shells were concavo-convex, had no striæ, and were strongly punctate. The interior of the dorsal valve was characterized by having three divergent ridges in front of the muscular area. *Stropheodonta nacrea* Hall, from the Corniferous and Hamilton, an unnamed species from the Corniferous, and *Stro-*

* See Hall and Clarke, vol. viii, pt. i, pp. 282, 283, figs. 19, 20; and pl. 20, fig. 30.

phomena lepis Bron., of the Middle Devonian from Eifel, Belgium, and the Asturias, were placed in this division.

The development of the hinge structure, form of shell, and convexity of valves is very similar in the three species (*S. inæquistriata*, *S. perplana*, and *P. iowaensis*) just described. The points of greatest difference are:

First: The Striæ.—*S. inæquistriata* produces new striæ by implantation, *S. perplana* by both implantation and bifurcation, while *P. iowaensis* has normally no striæ at any stage of development.

Second: Muscle Scars.—*S. inæquistriata* has a type very different from that of the other two, and in the ventral valve there is a change in the form of the muscles during the ephebic and gerontic stages. In the other two no such change has been observed.

3

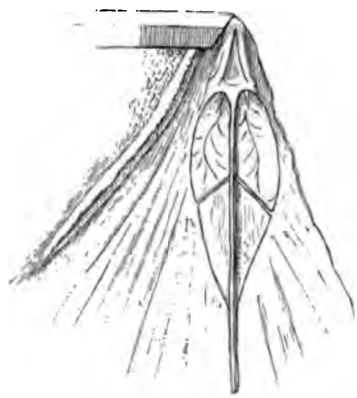

FIGURE 3.—*Stropheodonta junia* Hall; part of the muscle area of a ventral valve, showing the anterior and posterior elements of the adductors, and the pedicle muscle scar. × 3.

Comparing the scars in the ventral valves of *Stropheodonta junia* (figure 3), *S. perplana*, *S. demissa*, and *Pholidostrophia iowaensis*, it is at once seen that they are very similar. In each the diductors are broad, flabelliform, separated by a low septum, and bounded on their posterior lateral edges by more or less papillose ridges. Between the diductors are the elongate scars of the adductors, two pairs in each case. In the dorsal valves of *S. demissa*, *S. perplana*, and *P. iowaensis*, there is more variation in the form of the scars, but it is a variation in the form of the limiting structures rather than in the shape of the scars themselves. In each, there are two pairs of scars, one pair somewhat anterior to and between the members of the other pair. In *S. demissa* and *P. iowaensis*

they are bounded by a low ridge in front, while in *S. perplana* the anterior margin is more indefinite.

The interior of the dorsal valve of *P. iowaensis* should also be compared with that of *S. profunda* Hall, from the Niagara.* In that species the form of the scars is almost exactly the same as in the Hamilton species, and in front of the scars there are two short curved ridges and a prolongation of the median septum. This species has been put in the division Brachyprion by Hall and Clarke.

Thus there are examples of four of Hall and Clarke's subdivisions,—Brachyprion, Leptostrophia, Pholidostrophia, and Stropheodonta (*S. demissa* type), which agree in internal structure, but have great variation in external ornamentation. These facts would seem to indicate that the name Pholidostrophia should be given the same taxonomic value as the names Brachyprion and Leptostrophia, instead of being raised to generic rank.

Orthothetes chemungensis Hall.

Orthothetes chemungensis var. *pectinacea* Hall.

(Plate XV, Row 1.)

Pal. N. Y., iv, 1867, p. 67, pl. 10, fig. 6.

Orthothetes chemungensis var. *arctistriatus* Hall.

(Plate XV, Row 2.)

Pal. N. Y., iv, 1867, p. 71, pl. 9, figs. 1-12.

The specimens of *Orthothetes* in the present collection represent the two varieties *pectinacea* and *arctistriatus* of Hall. Both develop in the same manner, the only difference being in the time of appearance of new striæ. In the adult these two forms can be separated only under the most favorable circumstances, yet the younger specimens are quite distinct. The variety *pectinacea* has from 15 to 19 strong elevated striæ, between which are lower interspaces containing from 1 to 3 striæ. In the variety *arctistriatus* the striæ are so crowded that this alternating appearance is not obtained.

Smallest Shell.—The smallest shell which retains both valves is $\cdot 73^{mm}$ long and $1\cdot 1^{mm}$ wide, with a hinge width of 1^{mm}. Both valves are convex, and the cardinal area is high. The delthyrium is almost completely closed by a strong, convex deltidium which is slightly prolonged at the apex, forming an exsert pedicle tube. On this specimen there are 13 striæ on the dorsal and 14 on the ventral valve. At the beaks can be seen the outline of the nepionic shell, which is almost

* Loc. cit.

exactly circular, biconvex, and smooth. It is ·35^{mm} in length, but varies from that size to ·43^{mm}.

Introduction of New Striæ.—The shell of the variety *pectinacea* has, up to a length of 1 to 1·2^{mm}, from 13 to 15 sharp, simple striæ separated by spaces which are wider than the striæ. There then appear from 4 to 6 new striæ in the middle of the front, one implanted in each interspace in that region (figure 4). Specimen No. 1, on Plate XV, Row 1, shows the shell with the original striæ. Specimen No. 2 shows 5 striæ implanted in front. Later, more are implanted until there is one between each pair of the original striæ. The next step is the appearance of striæ in pairs, one on each side of each of the secondary striæ. (See specimens Nos. 8 and 10, Row 1, Plate XV.) At a still later stage more pairs are added, one on each side of those next previous to appear. In the variety *arctistriatus*, the method of development is the same, but the resulting appearance is somewhat different. In the earliest plicated stages there are from 15 to 19 sharp striæ. New striæ appear as before, but come in at earlier stages, thus covering the surface of the valve more completely and giving a more uniform appearance to the striæ. (Compare No. 6, Row 1, Plate XV, with No. 6, Row 2, and the last specimens in each row.)

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FIGURE 4. — *Orthothetes chemungensis* var. *pectinacea* Hall; dorsal valve, showing earlier plications. × 12.

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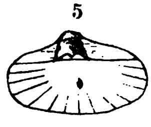

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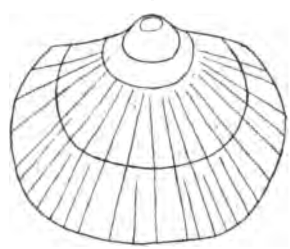

FIGURE 5.—*Orthothetes chemungensis* Conrad; specimen retaining both valves and showing pedicle tube and simple plications. × 16.

FIGURE 6.—The same species: ventral valve showing pedicle tube which is somewhat broken at top, growth lines, and striæ. × 16.

Orthothetes bellulus Clarke.

(PLATE XV, Row 3.)

13th Ann. Rept. N. Y. State Geol., pp. 176, 187, pl. iv, figs. 2–4.

This species was described by Clarke from specimens found in the Marcellus, but the Hamilton forms from the Canandaigua

Lake locality differ only slightly from the type. As described by Clarke, the Marcellus specimens have from 18 to 20 plications; the greatest diameter is at the hinge, and there is no umbonal distortion. The Hamilton specimens, however, have from 24 to 30 plications, the width at the hinge is less than that below, and the cardinal area is high, the ventral umbo being on that account frequently distorted.

The developmental stages offer nothing new. The shell in the nepionic stage is very small, usually from ·10 to ·12^{mm} in length. In young stages there is an exsert pedicle tube, while in the adult a strong convex deltidium covers the delthyrium.

Summary.—The development of two other species of *Orthothetes* has been worked out: That of *O. subplanum* of the Niagara, by Beecher and Clarke,* and that of *O. minutus* of the Salem limestone, by Cumings.† *O. bellulus* has in its adult stage many characters which agree with the neanic stages of *O. minutus.* The latter species has, in its earliest plicated stage, 18 plications, and more are added in the same way as in *O. bellulus.* In the adult, dwarfed, there are 40 plications.

Comparing the development of *O. subplanum* of the Niagara with that of *O. chemungensis*, many differences are found.

First: Convexity of Valves.—The nepionic shells of *O. chemungensis* have the valves subequally convex, which is the adult state of *O. subplanum*, while its nepionic shell is concavo-convex.

Second.—In *O. subplanum* the cardinal area is low compared with the length of the hinge line and the adults are symmetrical. In *O. chemungensis* only in the early neanic stages are the shells perfectly symmetrical usually, though some specimens retain the low cardinal area and symmetry into the late neanic stages.

Third: Surface Characters.—The duration of the nepionic stage is about the same in both species. In the youngest specimen of *O. subplanum* figured by Beecher and Clarke, 2·25^{mm} long, there are 17 striæ, 6 of which are secondary. A specimen of *O. chemungensis* of similar length has from 28 to 35 striæ.

Fourth: Hinge Structure.—The young of both species have a strong convex deltidium which is prolonged into an exsert tube for the passage of the pedicle. In *O. subplanum* the deltidium ceases to grow at an early stage, while in *O. chemungensis* the deltidium continues to increase in size throughout all the stages.

* Silurian Brachiopoda. Memoirs N. Y. State Museum, vol. i, No. 1, 1889, p. 23, pl. ii, figs. 14–20.

† Am. Geol., vol. xxvii, March, 1901, p. 147, pl. xv, figs. 1–11.

The first three of these differences point to an earlier acquisition of the characters through acceleration. The last would tend to show that *O. chemungensis* was in a progressive rather than a retrogressive line of development.

Chonetes coronatus Conrad.

(PLATE XVI, ROWS 3, 4.)

Pal. N. Y., iv, 1867, p. 133, pl. 21, figs. 9–12.

Chonetes scitulus Hall.

(PLATE XIV.)

Pal. N. Y., iv, 1867, p. 130, pl. 21, fig. 4.

Chonetes mucronatus Hall.

(PLATE XV, ROWS 4, 5.)

Pal. N. Y., iv, 1867, p. 124, pl. 20, fig. 1; pl. 21, fig. 1.

Chonetes robustus sp. nov.

(PLATE XVII, ROWS 1, 2.)

The New Species.—There are in the collection from Canandaigua Lake about 50 specimens of a *Chonetes* which differs in important characters from any described species. The shell is strongly concavo-convex, wider than long, with from 20 to 40 strong, sharp, equal striæ which increase toward the front by bifurcation and implantation. The umbo is smooth for a distance of from 1 to 2·5^{mm}, cardinal area of ventral valve narrow, concave, and the delthyrium covered by a convex deltidium. Pedicle opening minute, encroaching upon the ventral beak. The posterior margin of the area bears from 4 to 6 pairs of short divergent spines. For this species the name *Chonetes robustus* is suggested.

This species is more nearly related to *Chonetes coronatus* than to any other known brachiopod. It differs from it in the smaller size of the adult, the much greater convexity of the ventral valve, the fewer and coarser striæ at the same stage of growth, the smoothness of the umbos, the fewer pustules on the interior of the dorsal valve, and the later emergence of the first spines on the posterior margin. On the adult of this species there are 6 striæ in the space of 5^{mm} on the front, while in *C. coronatus* there are 11. In convexity and size this species resembles *C. mucronatus*, but is easily distinguished by the sharpness of the striæ and the angle of divergence of the spines.

The figures on Plate XVII are all enlarged two diameters.

Summary.—All the species in the collection have the same type of changes in development; hence they will be discussed together.

Protegulum.—The shell at this stage is exceedingly small and in none of the specimens of the present material are the beaks well enough preserved to show the protegulum. From Beecher's work it is known that in *C. scitulus*,* the protegulum is nearly circular in outline (·117^{mm} long and ·111^{mm} wide, according to the figure), with a strongly arcuate hinge.

Nepionic Stage.—The species agree in having the shell at this stage convex in the ventral valve, convex at the umbo, and concave or flat in front on the dorsal valve. This is an advance on the condition in *Stropheodonta*, where the dorsal shell is convex during the whole of the nepionic stage.

The ventral valve always has a narrow sinus, and the dorsal valve a corresponding median fold, with usually two less definitely marked lateral folds.

The outline is subcircular, though the width is frequently a little greater than the length. The hinge is somewhat arcuate. The length of the nepionic shell varies considerably in the different species, but is always less than one millimeter. It is least in *C. coronatus* and greatest in *C. mucronatus*.

7

FIGURE 7.—*Chonetes scitulus* Hall; ventral and dorsal valves, showing fold and sinus and plications of very young specimens. × 12.

Pauciplicate Neanic Stage.—In this stage new striæ are introduced by implantation and not by bifurcation of the older ones. The striæ are strong, simple, and separated by spaces as wide as the striæ themselves. The number of plications is not great. In *C. coronatus* and *C. scitulus* the largest number is usually 13 on the ventral valve and 12 on the dorsal. In the other species there are more, but usually less than 20.

The shell is about one-fifth wider than long and gently concavo-convex. The first spines, usually two or three pairs, appear during this stage. The size of the shell at the end of this stage, that is, when the striæ begin to bifurcate, is least in *C. scitulus*, when it is about 2^{mm} long, and greatest in *C. robustus*, where a length of 6·5^{mm} is reached. (See specimens Nos. 1–9, Plate XVI, Row 3; Nos. 1–6, Plate XIV, Row 1; Nos. 1–7, Plate XV, Row 4; Nos. 4, 6, 7, Plate XVII, Row 1.)

Later Neanic and Ephebic Stages.—It would be difficult to make any sharp line which would mark the end of the adolescent period and the assumption of all the adult characters. The size, convexity of valves, and number of striæ continue

* This Journal, vol. xli, 1891, p. 357, pl. xvii, fig. 14.

to increase during these stages, the width becomes greater in proportion to the length, and a number of pairs of spines are added on the cardinal margin.

Gerontic Stage.—Senile characters are not well shown except in *C. mucronatus.* In all, this stage seems to be accompanied by a thickening of the shell, a deepening of the muscle scars, and a growth of the anterior part of the shell, thus reproducing the early neanic conditions of length almost equal to breadth, and an increase in the convexity of the ventral valve.

Strophalosia truncata Hall.

(PLATE XVII, Rows 3, 4.)

Pal. N. Y., iv, 1867, p. 16, pl. 23, figs. 12–24.

Nepionic Shell.—Owing to the deformation of the ventral beak resulting from the method of attachment, very little can be made out concerning that valve in the youngest stages except that it is regularly and moderately convex. The beaks of some of the dorsal valves are extremely well preserved and show well the outlines of the protegulum and nepionic shell. The protegulum is transversely oval, with a gently curved posterior margin. In the best preserved specimen it is ·13^{mm} long and ·155^{mm} wide. The dorsal valve of the nepionic shell is subcircular in outline, with the hinge width about equal to the greatest width below. It is convex on the umbo and often for its whole length, though it is sometimes concave in front. The surface is smooth, without spines (figure 8).

Spines.—After the nepionic stage, spines are developed on both valves, but more numerously on the ventral valve. On the dorsal valve they are generally broken off close to the base. One specimen, however, retains two of the spines, which are long, slender, and lie against the surface of the valve. (See Plate XVII, Row 3, No. 11.) On the ventral valve they are better preserved. They are most abundant along the cardinal margin and stand erect, curving in toward each other from opposite sides of the beak, which suggests that they may have been of use in anchoring the shell. Over the rest of the surface the spines are directed forward.

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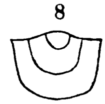

FIGURE 8.—*Strophalosia truncata* Hall; dorsal beak, showing protegulum and nepionic shell. × 16.

Anal Opening.—On the dorsal valve there is a convex chilidium, at the apex of which is the minute anal opening. The inner opening of this tube is at the anterior base of the cardinal process, just in front of the point where it bifurcates. (See Nos. 10 and 12, Row 3.) The cardinal process undergoes considerable change during the life stages. In early neanic stages

it is wider than long, projects little beyond the hinge line, and is divided once. In the adult it is longer than wide, deeply bifurcated in front, and quadrifid on the posterior face. (Compare Nos. 3 and 6, Row 3, with No. 12.)

Tropidoleptus carinatus Conrad.

(PLATE XVIII.)

Pal. N. Y., iv, 1867, p. 407, pl. 62, figs. 2, 3.

Nepionic Shell.—In the nepionic stage, the shell of this species is transversely oval to subcircular, with a hinge width less than the width below. Both valves are convex and smooth. In the early part of this stage the shell is distinctly wider than long, but just before the inception of the plications the length and breadth are about equal.

Changes during Development: Outline.—In the earliest neanic stages the shell becomes longer than wide, and this form is maintained until the shell reaches a length of from 4 to 7^{mm}, after which the width is greater than the length. (Compare the first ten specimens of the series with the last four on Plate XVIII.) From the early neanic through the adult stages the width of the shell at the hinge is greater than the width below, and the cardinal extremities are usually mucronate. In senile stages the width continues to increase without a corresponding growth on the posterior margin, which produces rounded cardinal extremities and gives the shell a transversely elliptical shape.

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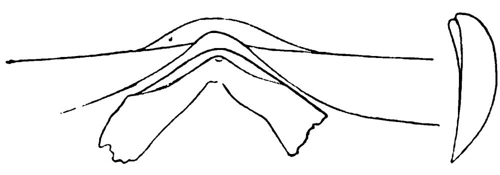

FIGURE 9.—*Tropidoleptus carinatus* Conrad; profile view, showing relative convexity of valves. × 9.

FIGURE 10.—Beaks of another specimen, showing pedicle opening and the wearing away of the ventral beak. × 6.

Convexity of Valves.—Up to a length of from ·75 to 1^{mm} both valves are slightly convex, with the pedicle valve somewhat the deeper. At this point, where the plications generally begin, the brachial valve becomes slightly concave, and continues so through the later stages (figure 9).

Plications.—Immediately after the nepionic stage plications arise on both valves, and apparently several are formed at once. On an individual $1{\cdot}6^{mm}$ in length there are 10 plications on the dorsal valve and 9 on the ventral. New plications

are added at the sides and never implanted, nor do they ordinarily bifurcate. In the adult there are from 17 to 21.

Gerontic Stage.—The senile characters in this species are: Hinge width less than the width below; strong varices of growth numerous; obliteration of the plications toward the front of the shell. The plications become flattened and indistinct toward the front of shells over 20^{mm} long.

Cardinal Process.—The cardinal process is large and prominent. It is joined in front to the bases of the crura and between them is a thickening of the shell, forming a platform which slopes forward to the floor of the valve. (See last figure on Row 3, Plate XVIII.) The posterior face of the process is smooth and rounded, and the lower third is covered by a strong chilidium, which also bounds the posterior ends of the dental sockets. The posterior wall of the cardinal process has, near the top, a narrow, rounded sinus formed by a shelly loop, which is continued forward and downward till it unites with the platform. On either side of this process is a deep conical hole, which extends nearly to the apex of the shell and probably represents the place of attachment of the diductor muscles. (See last figures on Rows 3 and 4, Plate XVIII. The platform has been broken away from the specimen at the end of Row 4, but the loop in the middle of the process and the two holes are well shown.)

Directly in front of the loop is a groove in the platform leading back to a minute anal tube, which runs along the middle line of the process and has its external opening in a pore just at the point where the chilidium meets the apex of the valve.

Trigeria lepida Hall.

Pal. N. Y., viii, pt. 2, 1893, p. 274, pl. 50, figs. 36–40.

Description of Smallest Specimen.—The smallest individual of this species is roughly triangular in outline, the rostrate beak, which projects $\cdot 25^{mm}$ beyond the hinge, forming the apex. The ventral valve is convex and smooth, without fold or sinus. The delthyrium is narrow and open. The dorsal valve is convex, and has a deep, narrow median sinus. The length of this shell is $1\cdot 09^{mm}$ and the width $\cdot 93^{mm}$. This form is very suggestive of the adult *Centronella* (figure 11).

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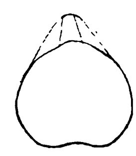

FIGURE 11.—*Trigeria lepida* Hall; young individual, before the inception of plications. x 16.

In the older specimens the beak is less prominent and in specimens more than $3\cdot 5^{mm}$ long the dorsal sinus becomes obliterated and both valves are convex. Shells more than

$1\cdot5^{mm}$ long have plications, the number increasing from 7 on a specimen of that length to about 18 on a specimen $5\cdot5^{mm}$ long.

12

FIGURE 12.—*Trigeria lepida* Hall; series showing the growth of the deltidial plates and the encroachment of the pedicle upon the ventral beak. ×8.

Deltidial Plates.—None of the specimens less than 3^{mm} long show any deltidial plates. In succeeding stages the plates appear as narrow triangles, one on each side of the delthyrium, and these triangles gradually become broader until they meet at the base. In the meantime, the pedicle encroaches upon the ventral beak so that an oval pedicle opening is formed in the adult (figure 12).

Eunella Lincklaeni Hall.

Pal. N. Y., iv, 1867, p. 397, pl. 60, figs. 49-65.

The list of changes in the form of this shell is not complete enough to offer anything new, but there are one or two interesting points in connection with the species.

Punctæ.—On the dorsal beak of the smallest shell ($1\cdot17^{mm} \times \cdot84^{mm}$) the first punctæ can be seen, and their arrangement agrees with that seen on the nepionic shell of *Terebratulina septentrionalis.** The first pair of punctæ is $\cdot07^{mm}$ from the

13 14 15

FIGURE 13.—*Eunella Lincklaeni* Hall; part of the loop of an adult specimen. ×8.
FIGURE 14.—Centronelliform stage of the loop. ×8.
FIGURE 15.—Side view of specimen shown in Figure 14; shell broken away to show the loop. ×16.

beak, and in front of them, on the median line, is a third one. Beyond this they are scattered sparingly over the surface for a

* E. S. Morse, Memoirs Boston Soc. Nat. Hist., vol. v, No. 8, 1902, pl. 62, fig. 15; also vol. ii, pt. i, No. 2, pl. 1, fig. 3.

short distance, but toward the front of the shell they become very numerous.

Brachidium.—The smallest specimen retaining the brachidium, and the only one in which the loop is complete, is about 4^{mm} in length. The loop extends about half-way to the front of the valve. The primary lamellæ run sharply upward and forward, and the anterior portions run about parallel to the floor of the valve, meeting at the front in an acute angle. As the two lamellæ approach each other they become wider, and, where they join, there is also a point directed backward (figures 14, 15). This is evidently an immature condition of the loop and differs greatly from the loop of the adult of this species. It agrees with the centronelliform stage of loop as described by Beecher and Schuchert.* This is the second genus of brachiopods in which this stage of loop has been observed, and its presence serves to confirm the view expressed in the paper referred to, that the *Centronella* form of loop is a primitive one for this superfamily of brachiopods. It differs slightly from the loop of *Dielasma turgida*† in that the lamellæ are narrower and the angle in front is less acuminate.

Cyrtina hamiltonensis Hall.

(PLATE XV, ROW 6.)

Pal. N. Y., iv, 1867, p. 268, pl. 27, figs. 1–4; pl. 44, figs. 26–33, 38–52.

Nepionic Stage.—The smallest individual in the collection represents this species in the nepionic stage. The shell is nearly circular in outline, and the length and breadth are the same,— ·53^{mm} (figure 16). The hinge line is ·32^{mm} long and

16 17 18 19

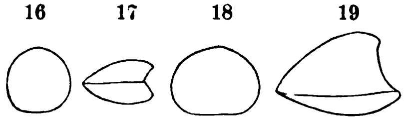

FIGURE 16.—*Cyrtina hamiltonensis* Hall; outline of the smallest specimen. ×28.
FIGURE 17.—A larger specimen; profile. ×16.
FIGURE 18.—The same; outline. ×16.
FIGURE 19.—A slightly older individual, showing the rapid change in the relative convexity of the valves. ×16.

nearly straight. The beaks of the two valves are elevated above the hinge line, and between them is the pedicle opening, which is shared by both valves. The valves are subequally convex and smooth, with no trace of fold or sinus (figures 17, 18).

* Proceedings Biol. Soc. Washington, vol. viii, p. 73, pl. x, fig. 1.
† Loc. cit.

Changes during Development: Convexity of Valves.—When the individuals become about ·75mm in length the valves are still nearly equally convex, and the ventral area is curved and inclined backward, so that the beak of that valve projects beyond the beak of the dorsal valve. In stages but little later, when the shell is slightly over 1mm in length, the ventral valve is four or five times as deep as the dorsal, and the ventral area becomes more erect, so that the beak is anterior to the hinge line.

Plications.—When the shell has reached a length of from ·45 to ·60mm a sinus is formed in the ventral valve and very soon after its initiation a fold is produced in the opposite shell. This stage, in which there is no other ornamentation than the fold and sinus, continues for some time. The largest specimen showing this state is 1·5mm long and 2·26mm wide. Shells at this period are almost globular and difficult to separate from the young of *Ambocœlia umbonata* unless carefully examined. (See No. 1, Row 6, Plate XV.)

The plications are introduced in pairs on the lateral margins, each pair coming in outside the older ones.

Spirifer mucronatus Conrad.

(PLATE XVI, ROWS 1, 2.)

Pal. N. Y., iv, 1867, p. 216, pl. 34, figs. 1–32.

Delthyris consobrinus d'Orbigny.

Pal. N. Y., iv, 1867, p. 222, pl. 35, figs. 15–23.

As the development of these two species is practically the same, they will be considered together.

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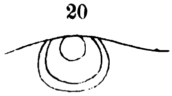


FIGURE 20. — *Spirifer mucronatus* Conrad; outline of protegulum and shell in nepionic stage; taken from a dorsal valve. × 28.

Protegulum.—On the beak of a well-preserved dorsal valve of *S. mucronatus* is the impression of the initial shell. It is circular, somewhat convex, with a curved hinge. The diameter is ·11mm (figure 20).

Nepionic Shell. — In the nepionic stage the shell is oval in outline, and broader than long. Both valves are convex, the ventral a little the deeper. The hinge width is less than the greatest width below. The surface is smooth, with no fold, sinus, or plications.

Neanic Stages.—In the earliest neanic stages a sinus is developed in the ventral valve, bounded by two strong ridges, which are the first plications. Following this a fold is formed in the dorsal valve and plications are added on the margins in pairs, each pair coming in outside the older ones. The later plications do not reach the beak.

In an early neanic stage the hinge width is the greatest width of the shell, the cardinal extremities soon become acuminate, and nearly all adolescent shells more than 5 or 6^{mm} wide are strongly mucronate. (Compare the first three shells of the series on Plate XVI with the older ones; also observe the growth lines on specimen No. 3, Row 2.)

It is interesting to note that in their early neanic stages these transversely elongated Devonian Spirifers pass through forms which correspond to the adult condition of certain Niagara species. The adult of *Spirifer crispus*, with a fold and 8 plications on the dorsal valve, and a hinge width nearly equal to the width below, corresponds very closely in these particulars, and in its index, with a specimen of *Spirifer mucronatus* about 2^{mm} long, and, except in the number of plications, with the specimen of *Delthyris consobrinus* 1^{mm} long.

Spirifer radiatus, with no plications, the width only one-seventh greater than the length, and the width at the hinge less than the width below, corresponds to a still earlier stage in the development of the present species.

Summary.

The foregoing descriptions show that the general deductions which have been previously drawn as to the character of the nepionic shell, the development of the pedicle tube and the deltidial plates, and the acquirement of surface characters, hold good in the families here studied for the first time. Other general facts will be noted under the families.

Centronellidæ.—The shape of *Trigeria lepida* in the nepionic stage is almost exactly that of adult *Centronella*, and thus another bit of evidence is added to that afforded by the loop, showing its relation to the Centronellidæ rather than to the Terebratulidæ. Going back to the very earliest stage, before the development of the dorsal sinus, the shell has characters common to the superfamily, that is, a biconvex shell with the ventral beak extended beyond that of the dorsal valve.

Terebratulidæ.—*Eunella*, in its early stages, is a rather simple, generalized type of shell, not differing greatly from the very youngest stage of *Trigeria*, but the development of its loop shows progress beyond the centronelliform stage. The position of the first three punctæ, which is the same as that in the recent genus *Terebratulina*, is interesting.

Terebratellidæ.—The evidence that *Tropidoleptus* belongs to this family has not been strengthened or diminished by the present studies. It still rests on the form of the loop as described by Hall, and later verified by Hall and Clarke. The development is similar to that of the Strophomenidæ, and the

articulation is like that in *Chonetes*. No deltidial plates are developed, and the pedicle is probably functional throughout life. The cardinal process is very large, and of a peculiar type, quite different from that of any of the Strophomenidæ.

Spiriferidæ.—The marked difference in shape and relative convexity of valves of *Cyrtina* in the early neanic stage, from *Spirifer* and *Delthyris* in the same stage, together with the geological range, would seem to indicate that, while both may be derived from the same ancestral stock, *Cyrtina* is not a modified *Spirifer*. *Delthyris*, *Spirifer*, *Ambocœlia*, and *Cyrtina* all start out with an equivalve nepionic shell and a pedicle opening shared by both valves. But with the first changes in later nepionic and early neanic stages, when the fold and sinus appear, *Cyrtina* and *Ambocœlia* become strongly inequivalve, while in *Spirifer* and *Delthyris* the valves retain for a short time their equality of convexity. In other words, the generic habit is assumed immediately after leaving the form that is common to all the members of the superfamily, and *Cyrtina* passes through no *Spirifer*-like stage.

Spirifer and *Delthyris* are so exactly alike in their external form in the youngest neanic stages that it is impossible to separate them.

Strophomenidæ.—The biconvex nepionic shells of *Stropheodonta*, with a median dorsal fold and ventral sinus (which may or may not be present), and the similar nepionic shells of *Chonetes* indicate a possible common origin in some shell of the *Triplecia* type, though not perhaps in that genus which thus far has not been found below the Calciferous, while *Rafinesquina*, which would seem to be the immediate ancestor of *Stropheodonta*, extends into the Chazy and probably lower, without any marked change in form. The early neanic stages of *Stropheodonta*, before the appearance of the crenulations on the hinge margin, are very similar to the adult *Rafinesquina*.

An interesting feature in the development of *Stropheodonta* is the marked mucronation of the cardinal extremities of the adolescent specimens. This mucronation disappears to a greater or less extent in the older stages. This same thing is noticed in *Spirifer*, and there many of the adults retain the mucronate forms, but they are only a phase in the life of the genus. In the ontogeny the outline changes from rounded forms in the nepionic and early neanic stages, through a mucronate form in the later neanic, and back to a rounded form in the adult or senile condition. The same things occur in the phylogeny of *Spirifer*, at least, for there are Niagara species with rounded cardinal extremities, then a great development of the mucronate types in the Lower and Middle Devonian, and a return to the rounded forms in the Carboniferous. A similar change is seen in *Platystrophia*.

The difference between the varieties *pectinacea* and *arctistriatus* of *Orthothetes chemungensis* is a good example of the effect of acceleration in the development of certain characters. The steps in the development of the two are exactly the same, but because the striæ are introduced at an earlier stage on one than on the other, the shells differ greatly in appearance.

Productidæ.—The facts in the development of *Chonetes* do not seem to support the idea put forward by Hall and Clarke that *Chonetes* might be descended from *Plectambonites*, a shell which in many respects much resembles *Chonetes*. The early neanic stages have an outline which is much the same as that of *Rafinesquina* and *Stropheodonta*. The resemblance of the nepionic shell to *Triplecia* has already been referred to, and this, with the other characters, relates the shell to the Strophomenidæ. It is clearly a transition form between the latter family and the Productidæ.

Paleontological Laboratory,
Yale University Museum,
January 6, 1904.

EXPLANATION OF PLATES.*

Plate XII.

Pholidops oblata Hall.

Rows 1 and 2.—Series of dorsal valves. × 2.
Rows 3 and 4.—Series of ventral valves. × 2.

Plate XIII.

Row 1.—Partial series of *Stropheodonta perplana* Conrad; ventral valves. Specimens Nos. 3—9 show well the mucronate cardinal extremities of the adolescent individuals.

Rows 2–4.—Series of *Stropheodonta inæquistriata* Conrad; ventral valves, showing the shells in neanic, ephebic, and gerontic stages.

Plate XIV.

Chonetes scitulus Hall.

Rows 1 and 2.—Series of ventral valves. × 2.
Rows 3 and 4.—Series of dorsal valves: interior view. × 2.
Specimens Nos. 1 and 2 of Row 1, and Nos. 1 and 2 of Row 3, show the ventral sinus and dorsal fold of the very young stages. Most of the specimens in Row 4 show the brachial scars.

Plate XV.

Row 1.—Partial series of *Orthothetes chemungensis* var. *pectinacea* Hall; dorsal valves. × 2.

Row 2.—Partial series of *Orthothetes chemungensis* var. *arctistriatus* Hall; dorsal valves. × 2.

* Unless otherwise stated, the figures are natural size.

Row 3.—Partial series of *Orthothetes bellulus* Clarke; dorsal valves. ×2.
Rows 4 and 5.—Series of *Chonetes mucronatus* Hall; ventral and dorsal valves. ×2.
Row 6.—Series of *Cyrtina hamiltonensis* Hall; dorsal valves. ×2.

PLATE XVI.

Rows 1 and 2.—Partial series of *Spirifer mucronatus* Conrad; dorsal valves.
Row 3.—Series of *Chonetes coronatus* Conrad; ventral valves, exterior.
Row 4.—The same; dorsal valves, interior.

PLATE XVII.

Rows 1 and 2.—Series of *Chonetes robustus* Raymond; ventral and dorsal valves. ×2.
Rows 3 and 4.—Series of *Strophalosia truncata* Hall; dorsal and ventral valves. ×2.

PLATE XVIII.

Tropidoleptus carinatus Conrad.

Rows 1 and 2.—Series of ventral valves.
Rows 3 and 4.—Series of dorsal valves.

Art. XXVII.—*Studies in the Cyperaceæ*; by Theo. Holm. XXI. New or little known species of *Carex*. (With figures in the text, drawn by the author.)

Carex neurochlæna sp. n. (figs. 1–2).

Rhizome slender, ascending, stoloniferous, the leafsheaths persisting, light brown; leaves shorter than the culms, very narrow, carinate, scabrous; culms up till 24^{cm} in height, curved, almost capillary, trigonous, scabrous below the inflorescence, otherwise glabrous, phyllopodic; spikes two to four, gynæcandrous or the lowest one sometimes purely pistillate (fig. 1), small and few-flowered, roundish, contiguous or the lowest one remote, reddish brown, the bracts inconspicuous or the lowest one with a filiform blade much shorter than the inflorescence; scales broadly ovate, those of the staminate flowers acute, the others obtuse, reddish brown with green midrib and hyaline margins; perigynium (fig. 2) longer, but narrower than the scale, sessile, slightly spreading, broadly elliptical, attenuated at both ends, plano-convex, wingless, prominently nerved, greenish, the beak short, slit on the convex face; stigmata two.

Collected above Rink rapids, Yukon River in Yukon, by Professor John Macoun (No. 53,879).

This species belongs to the *Neurochlænæ*.

Carex vagans sp. n.

Rhizome horizontally creeping, forming dense mats, the leaf-sheaths persisting, light brown; leaves glaucous, shorter than the culms, very narrow, carinate, scabrous; culms numerous, from 20 to 30^{cm} in height, very slender and weak, triangular, scabrous, phyllopodic; spikes three to five, androgynous or the lateral purely pistillate, small and few-flowered, sessile, forming an interrupted, spicate inflorescence about 2^{cm} in length, the bracts short and inconspicuous; scales ovate, acute, reddish brown with green, broad midrib and hyaline margins, shorter than the perigynium; perigynium sessile, somewhat spreading at maturity, ovoid, plano-convex, wingless, two-ribbed (the marginal), light brown, minutely scabrous along the very short beak, deeply slit on the convex face; stigmata two.

Collected in Oregon: Steins Mts., flat opposite Andrews, alt. 1950^{m}, by Mr. John B. Leiberg (No. 2558).

In aspect much like *C. occidentalis* Bail., but in this the spikes are more dense-flowered, the perigynium elliptical, stipitate, spongious at the base and the beak prominently bidentate.

Carex phæolepis sp. n.

Rhizome short, creeping, the leaf-sheaths persisting, light brown; leaves light green, a little shorter than the culms, narrow, but flat, scabrous; culms not numerous, from 25 to 35^{cm} in height, slender, but stiff, erect, triangular, scabrous, phyllopodic; spikes four to eight, androgynous and the staminate portion very prominent in all of these, ovate, rather small, sessile and contiguous or the lower ones remote, the bracts inconspicuous; scales ovate-lanceolate, mucronate, light brown with broad hyaline margins and greenish midvein, longer than the perigynium; perigynium almost sessile, erect, broadly elliptical, plano-convex, wingless, two-ribbed (the marginal), colorless, minutely scabrous along the short beak, which is slit on the convex face; stigmata two.

Collected in Eastern Oregon: Bear Butte, Crook County, alt. 1710^{m}, by Mr. John B. Leiberg (No. 335).

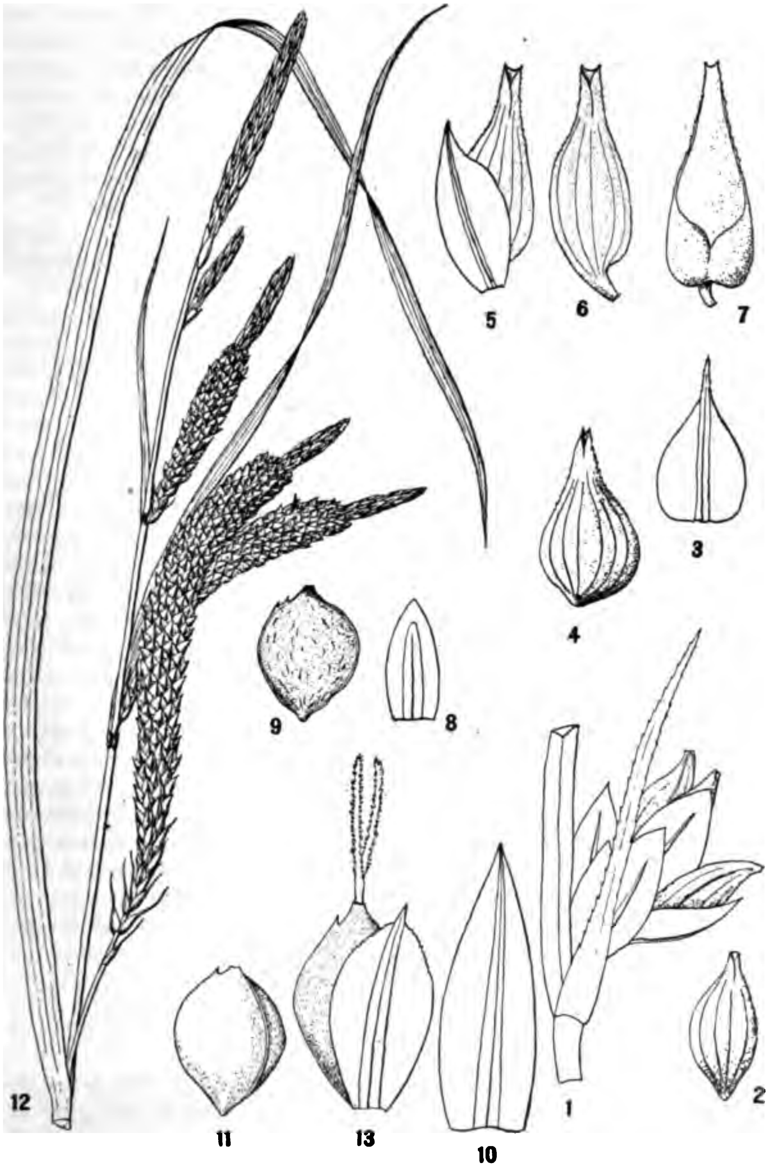
Carex chrysoleuca sp. n. (figs. 3–4).

Rhizome wanting, but apparently cæspitose, the leaf-sheaths fibrillose, light brown; leaves light green, about half as long as the culms, narrow, carinate, scabrous; culms from 40 to 55^{cm} in height, stiff, erect, trigonous, scabrous near the inflorescence, otherwise glabrous, phyllopodic; spikes about twenty, the lowest ones decompound, androgynous and the staminate portion very prominent, ovate, small in comparison to the size of the plant, sessile and contiguous, the bracts inconspicuous or the lowest one sometimes elongated, setiform; scales of staminate flowers lanceolate, sharply pointed, hyaline to light yellowish brown, those of the pistillate flowers (fig. 3) ovate with the midvein extended into a conspicuous awn, hyaline to yellowish, shorter than the perigynium; perigynium (fig. 4) sessile, erect or slightly spreading, broadly ovate, plano-convex, wingless, prominently several-nerved on convex face, light brown or greenish, scabrous along the distinct beak, which is deeply slit on the convex face; stigmata two.

Collected near Mariposa, California, by Mr. J. W. Congdon.

Carex vitrea sp. n. (figs. 5–7).

Rhizome wanting, but apparently cæspitose, the leaf-sheaths persisting, light brown; leaves glaucous, longer than the culms, narrow, flat, very scabrous; culms from 60 to 65^{cm} in height, slender, triangular, scabrous, phyllopodic; spikes numerous, decompound, forming an interrupted spicate inflorescence, up till 8^{cm} in length, androgynous, the staminate portion very prominent, sessile, the lower bracts setiform, short; scales of



Carex neurochlæna, figs. 1–2; *C. chrysoleuca*, figs. 3–4; *C. vitrea*, figs. 5–7; *C. dives*, figs. 8–9: *C. Schottii*, figs. 10–11; *C. lacunarum*, figs. 12–13. (Explanation in text.) The figures 1–11 and 13 are magnified; fig. 12 represents the natural size.

staminate flowers lanceolate, mucronate, hyaline with green midvein, those of the pistillate flowers (fig. 5) ovate, acuminate and mucronate, hyaline, much shorter than the perigynium; perigynium stipitate, nearly erect, ovate-lanceolate, plano-convex, spongious at the base, wingless, several-nerved on the convex (figs. 5–6), nerveless on the plane face (fig. 7), light green to almost hyaline, scabrous along the narrow beak, which is emarginate and deeply slit on the convex face; stigmata two.

Collected at Palm Springs (Agua Caliente), desert base of San Jacinto Mountain, at an elevation of 500–700 ft., in Southern California, by Mr. S. B. Parish (No. 4144).

The last three species: *C. phæolepis*, *chrysoleuca* and *vitrea* are characteristic by the staminate portion of their spikes being very prominent, and by this character they are readily distinguished from all other members of the *Acanthophoræ*. However, there is a fourth species "*C. vallicola*" described by Dewey* which is said to exhibit the same peculiarity: "having the staminate part of the spikelet a short projecting column or cylinder at the apex, often longer than the pistillate part," and we thought at first that one of our species might be identical with this. But the perigynium of *C. vallicola* is described as "obovate, tapering below, rostrate and stiped, at the orifice oblique," besides "being nerveless," thus showing a marked distinction from the structure of the perigynia possessed by our species. Dewey's plant was collected in Jackson's Hole, on Snake River, at an elevation of 6000 ft., by Dr. F. V. Hayden, but the specimens which the writer has had the opportunity to examine, were so young and poorly represented, that they gave no illustration of the species whatever, and as we have learned from Mr. Clarke, there is no material of it in the Kew Herbarium. So far, *C. vallicola* stands as an imperfectly known species, but is evidently a near ally of those three, described above.

Carex venustula sp. n.

Rhizome matted with short stolons, the scale-like leaves brown, becoming fibrillose; basal leaves as long as the culm, narrow and flat, slightly scabrous, the cauline much shorter, but with long sheaths; culm about 42^{cm} in height, slender and weak, triangular, scabrous, aphyllopodic; spikes three to four, the terminal staminate, clavate, the lateral pistillate or the uppermost sometimes androgynous, contiguous, all borne on filiform peduncles, drooping, short and dense-flowered, subtended by sheathing bracts, of which the lowest one has a blade about as long

* This Journal, II, vol. xxxii, 1861, p. 40.

as the inflorescence; scale of staminate flower oblong, obtuse, reddish brown with green, not excurrent, midvein; scale of pistillate flower spathulate oblong, obtuse to aristate, deep purplish to almost black with the midvein obsolete, narrower than the perigynium; perigynium stipitate, erect, elliptical oblong, minutely granular above, two-nerved, pale green with purplish spots above, the beak short, emarginate; stigmata three or, sometimes, two, the style not exserted.

Alaska: Chistachina River, lat. 63, between Cook inlet and the Tanana River, collected by Captain E. F. Glenn, and British Columbia: Glacier, alt. 4122 ft., by Zoë W. Palmer.

Carex venustula is a near ally of *C. Montanensis* Bail., although it would not seem so if we compare the diagnoses alone. For it is hard to understand how specimens of authentically determined *C. Montanensis* can be described as belonging "to the Rigidæ, being allied to *C. Tolmiei*, yet having the habit of *C. Magellanica*." The diagnosis* is very incomplete and in several points incorrect. However, the main distinction between the two depends especially upon the structure of the scales and the perigynium: the former being about as long as the very broadly elliptical perigynium in *C. Montanensis*, while in the other species the scales, obtuse to aristate, are much shorter than the elliptical oblong perigynium. Common to both are the long-peduncled drooping spikes of dark color, the short stem-leaves and aphyllopodic culms.

Carex microchæta sp. n.

Rhizome stoloniferous with persisting, brownish scale-like leaves; leaves shorter than the culm, broad, flat and scabrous along the revolute margins; culm from 10 to 20^{cm} in height, erect, coarse and stiff, triangular, scabrous, phyllopodic; spikes three to four, the terminal and, sometimes, the uppermost lateral staminate, the others pistillate, contiguous, erect, sessile, or the lowest one shortly peduncled, all short, thick and dense-flowered, subtended by sheathing bracts with the blades shorter than the inflorescence; scales of staminate and pistillate flowers, elliptical oblong, acuminate, purplish black with pale midvein extended into a short, scabrous awn, longer but narrower than the perigynium; perigynium stipitate, erect, elliptical, granular, two-nerved, purplish spotted above, whitish below, the beak short, bifid; stigmata three, the style exserted.

Yukon: Klondike, Indian Divide, collected by Professor John Macoun (No. 53,877).

The affinity is with *C. Tolmiei* and *C. spectabilis* of the *Melananthæ*.

* Botanical Gazette, 1892, p. 152.

Carex spectabilis Dew.*

This species, although well defined by Dewey (l. c.), has been overlooked by several authors and has been described as new "*C. invisa* Bailey," or confounded with various other species, for instance, with *C. macrochæta* Mey. var. *pseudopodocarpa* Kükthl., and *C. podocarpa* R. Br. We can add nothing to the diagnosis except that the culm is aphyllopodic, and that the scale-like leaves of the densely matted rhizome become fibrillose. It is said to have been originally collected in "the Arctic Region," but since then it has been found in several places in the mountains of British Columbia, Washington and California. In regard to *C. podocarpa* R. Br. we might state that Mr. C. B. Clarke has informed us that a careful examination of Robert Brown's specimen has convinced him that it is merely a young specimen of *C. rariflora* Sm.

Carex vulgaris Fr.

This plant offers an excellent example of a species distributed over a wide geographical area and possessed of great plasticity in respect to variation throughout the northern hemisphere. And so numerous are the varieties that Fries thought it would require a book to enumerate and describe them all; moreover, the variation is expressed in quite a distinct way wherever the plant occurs, in northern Europe or in the northwestern parts of this continent, where the species appears to be best represented. The species was already known to Tournefort and Ray as "*Cyperoides*" and "*Gramen*," while Linnæus was the first to describe it as a "Carex": *nigra verna vulgaris* (Flora Lapponica No. 330). Since then it has been described as *C. Goodenoughii* by Gay; a name, however, that only applies to the variety "*stolonifera*," while the typical form, as it occurs in Lapland, has received the name "*vulgaris*" by Elias Fries (Mant., III, p. 153). The plant is so well known and so well described that it is not necessary to reproduce the diagnosis *in toto* for the sake of illustrating the species as it occurs on this continent, but we might quote a few words about the structure of the perigynium. This organ is by Fries (l. c.) described as being subsessile, persisting, roundish-elliptical, many-nerved and longer than the obtuse scales; that the perigynium, sometimes, is nerveless, is evident from the description in Hartman's Flora of Scandinavia (11th edit.). If we now examine some of the most characteristic European varieties, Danish, Norwegian, Swedish and German specimens for instance, the perigynium appears with an outline of from roundish to very narrow elliptical, with a short stipe or strictly

* This Journal, vol. xxix, p. 248, 1836.

sessile, with the surface granular to densely verrucose, with or without a few spinulose projections along the upper margins, with the orifice of the short beak wholly glabrous or minutely spinulose, and finally with many very prominent nerves, with only a few and quite faint or apparently with none at all, the two marginal nerves being usually obsolete. Accompanying these perigynial structures a pronounced variation in habit occurs: in respect to the rhizome, the relative position of the pistillate spikes, the length of the peduncles, the length of the spikes, of the bracts, etc., distinctions that have proved to be sufficiently valid for establishing a number of varieties, especially in Northern Europe. Among these are, for instance, "*tornata* Fr.," which is densely cæspitose, with thick, rigid culms, broad leaves and heavy spikes, "*juncea* Fr.," a very slender form with convolute, filiform leaves and remote spikes, "*stolonifera* (Hoppe)" with long stolons and short, curved culms, "*longe pedunculata* Blytt" with the culms, tall, nodding at the apex and with long-peduncled, dark spikes of which the scales are acute and longer than the perigynia, "*rigida* Blytt" which grows in dense tufts and of which the culms and leaves are very stiff and scabrous, besides the pistillate spikes are very long, linear and often androgynous, "*atra* Blytt" with slender culms, and black, sessile spikes, mostly in a dense head, and "*anomala* Blytt" with the terminal spike gynæcandrous. By studying the species as it is represented in this country, we have seen the typical *C. vulgaris* from Alaska, Colorado, Cape Breton Island and Nantucket, Massachusetts, while the var. *stolonifera* has been collected in Labrador. It appears, however, as if the species is best represented in the northwestern parts of this continent — Alaska and Yukon, where certain varieties have been collected in large quantities and at several stations. Of these we propose as new

var. *limnophila* nob.

Rhizome densely cæspitose; culms curved, only about 10^{cm} in length; spikes very short and thick, sessile and contiguous, almost capitate, the terminal mostly gynæcandrous; perigynium stipitate, elliptical, denticulate near the beak, purplish spotted above.

Collected on St. Paul Island, Bering Sea, growing in mud by marshes. Mr. James M. Macoun (No. 16,613); also on a nunatak in Columbia glacier, Prince William's Sound, by Messrs. Coville and Kearney (No. 1365).

This variety bears a strong resemblance to *C. rufina* Drej., from which it differs only in its more robust habit and the

structure of the perigynium. However, it is interesting to see that some Scandinavian authors are inclined to consider *C. rufina* as a reduced form of *C. vulgaris.*

var. *hydrophila* nob.

Rhizome very slender, stoloniferous, the scale-like leaves persisting, shining, purplish brown; leaves about as long as the very slender culms, narrow but flat; spikes cylindrical, dense-flowered, peduncled, erect or somewhat spreading; perigynium prominently stipitate, roundish-elliptical, wholly glabrous and nerveless.

Yukon: in water, Colorado Creek, collected by Professor John Macoun (No 53,843).

var. *lipocarpa* nob.

Rhizome densely cæspitose with persisting, light brown sheaths; leaves glaucous, narrow but flat as long as the culms; culms from 15 to 40^{cm} in height, slender, but erect; spikes long and very dense-flowered except towards the base, more or less peduncled, especially the lowest one, which is often developed from near the base of the culm and branched; bracts foliaceous and quite long; perigynium with a long stipe, elliptical, glabrous, many-nerved, the beak very distinct and proportionately long.

Collected in Alaska at several stations, on Vancouver Island, in the Selkirk Mountains, British Columbia, and in the Chilliwack Valley, by Mr. James M. Macoun and others.

The fact that the perigynium is early deciduous in this variety has led several authors to the belief that it is identical with the South American *C. decidua* Boott, but the terminal spike is, in this species, nearly always gynæcandrous and the perigynium is oblong-ovate, denticulate-serrate.

Some of the specimens from Alaska were sent to Mr. C. B. Clarke of Kew, who kindly informed the writer that these were identical with Scouler's Columbia River plant, which Boott first named *C. decidua*, but afterwards corrected to *C. vulgaris* Fr.

The so-called *C. interrupta* Bcklr. var. *impressa* Bailey is, also, according to Mr. Clarke, a form of *C. vulgaris*, and almost like the typical plant.

var. *elatior* Lang.

Rhizome cæspitose; culms and leaves until 55^{cm} in length, very slender; spikes sessile, cylindrical and dense-flowered, some

what remote, subtended by short, filiform bracts; perigynium elliptical, stipitate, many-nerved, glabrous.

Nova Scotia: Halifax, collected by Professor John Macoun (No. 16,678). The specimens were identified as var. *strictæformis* Bail., but they do not differ in any way from our European material, although the nerves of the perigynium are not always as prominent as in the American plant.

In comparing these North American varieties of *Carex vulgaris* with the European, we notice as a prominent feature for distinguishing these the strong development of the stipe in the former, and sometimes to such an extent as making the perigynia early deciduous. In the European forms the stipe is often very distinct, but seldom as long and slender as in the American. In regard to the nervation, the perigynium shows, as already stated, several variations, and a prominently many-nerved perigynium seems to be the most frequent among the representatives in this country.

The beak is, as a rule, very short in all European specimens, also in the American with the exception of the var. *lipocarpa*, where it is quite prominent.

There is, still, another plant which may belong here, but of which the writer has only studied a scant supply of material. This is *C. Kelloggii* W. Boott, which seems very near the typical *C. vulgaris*, by the very short beak and stipe of the perigynium.

Carex sphacelata sp. n.

Rhizome ascending, stoloniferous with persisting, deep reddish brown scale-like leaves; leaves about as long as the culm, rather broad and flat, glabrous; culm from 30 to 40^{cm} in height, erect, stiff, triangular, glabrous, phyllopodic; spikes three to five, the terminal and, sometimes, the uppermost lateral staminate, the others pistillate, contiguous or the lower ones remote, sessile or short-peduncled, erect, dense-flowered, subtended by foliaceous, sheathless bracts with the blades broad and longer than the inflorescence; scale of staminate flower linear-lanceolate, obtuse, deep brown with pale midrib; scale of pistillate flower ovate-lanceolate, almost black with the midvein obsolete, shorter and much narrower than the perigynium; perigynium stipitate, erect, broadly elliptical, granular, two-nerved, purplish-spotted above, whitish below, the beak short, entire; stigmata two, the style enclosed.

Collected in Yukon: Colorado Creek, by Professor John Macoun (No. 53,847).

This species may be placed near *C. aquatilis* Wahl.

Carex chionophila sp. n.

Rhizome cæspitose with persisting, brown leaf-sheaths; leaves longer than the culm, narrow but flat, scabrous; culm from 30 to 40^{cm} in height, erect, slender, trigonous, scabrous, phyllopodic; spikes four to five, the terminal staminate, the lateral pistillate or with a few staminate flowers at the apex, contiguous, sessile or the lowest one peduncled, erect, dense-flowered, cylindric and until 4^{cm} in length, subtended by sheathless bracts with blades about as long as the inflorescence; scale of staminate flower oblong, obtuse, purplish with pale midvein; scale of pistillate flower ovate-oblong, obtuse, black with pale midvein, shorter and much narrower than the perigynium; perigynium minutely stipitate, erect, pyriform, granular above, nerveless, light green above, whitish below, the beak very short, entire; stigmata two or three.

Collected in a brook, West Dawson, Yukon, by Professor John Macoun (No. 53,849).

Allied to *C. sphacelata* but is readily distinguished by the characters enumerated above; it is altogether a more graceful plant with slender culms and narrower leaves, besides of a much lighter color.

Carex consimilis sp. n.

Rhizome horizontal, stoloniferous with persisting light brown scale-like leaves; leaves about as long as the culm, narrow with revolute margins, scabrous; culm about 25^{cm} in height, erect, stiff, triangular and scabrous, phyllopodic; spikes four, the terminal staminate, the lateral pistillate or sometimes androgynous, contiguous, sessile or the lowest one short-peduncled, erect, subtended by very short, sheathless bracts; scale of staminate flower linear-lanceolate, light brown; scale of pistillate flower ovate-lanceolate, acute to obtuse, black with the midvein obsolete, longer, but narrower than the perigynium; perigynium minutely stipitate, erect, orbicular, granular above and sharply denticulate along the upper margins, two-nerved, purplish spotted above, light brownish green below, the beak short, entire; stigmata two, style short but exserted.

Collected near Klondike, Indian Divide, Yukon, by Professor John Macoun (No. 53,878).

In habit not unlike *C. hyperborea* Drej., but the perigynium is very different.

Carex cyclocarpa sp. n.

Rhizome stoloniferous with persisting, purplish scale-like leaves; leaves shorter than the culm, flat, but narrow; culms from 12 to 42^{cm} in height, slender, but erect, or slightly curved,

triangular, scabrous, phyllopodic; spikes three to four, the terminal staminate, the lateral pistillate or, sometimes, the upper one androgynous, contiguous, sessile or the lowest one peduncled, erect, dense-flowered, short, subtended by bracts, of which only the lowermost is foliaceous, shorter than the spike and with black auricles; scale of staminate flower linear-lanceolate, brown with pale midvein; scale of pistillate flower ovate, obtuse, black with the midvein obsolete, shorter and much narrower than the perigynium; perigynium shortly stipitate, erect, turgid, nearly globose, granular, two-nerved, brownish green with purplish spots above, the beak minute, entire; stigmata two or three, the style exserted.

Grows in tufts in woods and in boggy places: West Dawson, mountains back of Dawson, Hunker Creek, Yukon, collected by Professor John Macoun (Nos. 53,842, 53, 55, and 58). This together with the preceding, *C. consimilis*, are no doubt close allies, but they appear so distinct from the other *Microrhynchæ*, that their place within the section seems uncertain. In some respects they resemble *C. vulgaris* and *C. rigida*, in others *C. cæspitosa* and *C. lugens*, yet they may "ad interim" be placed with *C. nudata* between *C. aquatilis* and *C. interrupta*, as indicated in "Greges Caricum."

Carex limnocharis sp. n.

Rhizome stoloniferous with persisting, purplish scale-like leaves; leaves as long as the culm, rather narrow, flat, scabrous; culm 30^{cm} in height, erect, but curved at the apex, triangular, glabrous, phyllopodic; spikes five, the terminal staminate, the lateral pistillate or the uppermost androgynous, contiguous, peduncled, spreading, not very dense-flowered, about 5^{cm} in length, but thin, subtended by sheathless, foliaceous bracts, much longer than the inflorescence; scale of staminate flower linear-lanceolate, acute, light brown; scale of pistillate flower ovate acuminate, reddish brown with green, not excurrent midrib, narrower but longer than the perigynium; perigynium stipitate, erect, broadly elliptical, granular above, nerveless, pale green, the beak short, entire; stigmata two, style enclosed.

In muddy places, Klondike River, Yukon, collected by Professor John Macoun (53,846).

Allied to *C. acutina*, but more robust; a beautiful species with long, slender spikes of reddish brown color, in habit much like the European *C. prolixa* Fr.

Carex millegrana sp. n.

Rhizome wanting, but apparently cæspitose with persisting reddish-brown leaf-sheaths: leaves shorter than the culm, nar-

row, but flat, scabrous; culms until 60^{cm} in height, slender, triangular, scabrous, phyllopodic; spikes five to six, the terminal staminate, the lateral pistillate or the uppermost androgynous, contiguous, nearly sessile, spreading to almost drooping, from 4 to 8^{cm} in length, slender, but very dense-flowered except towards the base, subtended by sheathless bracts with very short blades, the lowest barely half as long as the inflorescence; scale of staminate flower elliptical oblong, pale reddish-brown with green midvein; scale of pistillate flower elliptical, a little darker, spreading and somewhat shorter than the perigynium; perigynium sessile, elliptical, granular, compressed, prominently two-nerved (the lateral), pale greenish brown, the beak short, emarginate: stigmata two.

South Dakota; Rosebud Creek, collected by Mr. E. J. Wallace.

In general habit much like *C. angustata*, but we prefer, nevertheless, to place it near *C. lenticularis*.

Carex dives sp. n. (figs. 8–9).

Rhizome wanting, apparently cæspitose, lower leaf-sheaths light-brown, not fibrillose; leaves as long as the culm, quite broad and flat, scabrous along the margins; culms up till 60^{cm} in height, erect, stiff, triangular, very scabrous, phyllopodic; spikes from six to seven, the terminal and uppermost one or two lateral staminate, the others pistillate, more or less remote and peduncled, especially the lowest one, nodding, very dense-flowered, from 4 to 10^{cm} in length, subtended by sheathless, foliaceous bracts of which the lower ones reach high above the inflorescence; scale of staminate flower linear-oblong, mucronate, pale brown with green midvein; scale of pistillate flower (fig. 8) lanceolate oblong, acute, purplish with green midvein, much narrower, but about as long as the perigynium; perigynium (fig. 9) minutely stipitate to sessile, erect, roundish, compressed, granular, two-nerved, sparingly denticulate along the upper margins, pale green with scattered purplish spots and streaks, the beak very short, entire; stigmata two.

Collected in Oregon by Mr. L. F. Henderson; in California: "in open swamps with *C. utriculata*, 12 mile house San Jose R. R." collected by H. N. Bolander, and in Chilliwack Valley, British Columbia, by Mr. James M. Macoun.

The affinity is with *C. Sitchensis* Prescott.

Carex salina Wahl.

The statement that "this species does not occur on the western side of this continent"* is a mistake, since it has been

* Memoirs Torrey Bot. Club, i, 45, 1889.

collected at several stations on the Alaskan coast, sometimes associated with its near ally, *C. subspathacea* Wormskj.

Carex hæmatolepis Drej.

Described by Drejer* as follows: "Spica mascula 1, femin. 3–5 elongatis cylindraceis laxifloris in pedunculo lævi valido erectiusculis v. demum nutantibus, squamis ovatis acutis serrulato-mucronulatis perigynia ovali-ovata substipitata subsuperantibus, stigmatibus 2–3". "Squamæ ♀ atro-sanguineæ tenuissime punctulatæ nervo tenuissimo discolore, ovatæ, acutæ serrulato-aristatæ v. muticæ, perigynia fere tegentes et superantes. Perigynia obsolete nervata decolora stramineo-viridia, rostro brevissimo integro." Only known from Greenland, but may be found on the northeastern coasts of this continent. It shows some resemblance to *C. cryptocarpa*, but differs from this by the nearly erect pistillate spikes, the mucronate scales and the much narrower perigynia.

Carex cryptocarpa C. A. Mey.

To American botanists this species is so well known and well understood that it should hardly be necessary to make any further mention of it as a little known species. However in a recently published paper dealing with Arctic *Carices*,† the species is enumerated as identical with *C. Lyngbyei* Hornem., with *C. filipendula* Drej. and with *C. capillipes* Drej. and has received the new name *C. Lyngbyei* Hornem., this being older than the name of Meyer. If now the diagnosis of these four formerly recognized species had been drawn up so as to demonstrate their identity, we should have no objection to make, but it seems to us that a comparison of the plants themselves and the original diagnoses makes it rather unnatural to combine them as only one, a fact that becomes more evident when we examine the renewed description of *C. Lyngbyei* (l. c.).

Habitually these four species are somewhat like each other, but *C. cryptocarpa* is readily distinguished by being very robust with broad leaves and heavy spikes, while the others, especially *C. Lyngbyei*, is exceedingly slender in all its parts. The specific characters are, however, to be drawn from the structure of the scales of the pistillate spike and of the perigynium, and we have noticed the following distinctions: The scale is in *C. cryptocarpa:* oblong to oblong-lanceolate, acute with a broad midvein; in *C. Lyngbyei:* lanceolate with the midvein extended into a very long, serrulate awn; in *C. fili-*

* Revisio critica Caricum borealium (Naturhist. Tidsskr. Kjöbenhavn 1841).
† Ostenfeld, C. H., Flora Arctica, Copenhagen, 1902, p. 75.

pendula: ovate, acute to aristulate; in *C. capillipes:* ovate-lanceolate, mucronate. The perigynium is in *C. cryptocarpa:* broadly elliptical, minutely scabrous along the upper margins, and with the veins hardly visible; in *C. Lyngbyei:* obovate, glabrous, prominently veined; in *C. filipendula:* oval to obovate, glabrous, obsoletely veined; in *C. capillipes:* subovate, scabrous along the upper margins, obsoletely veined. In Flora Arctica the description of these four species "*C. Lyngbyei*" reads thus: "scales three-nerved, acuminate with elongated midvein longer than the faintly nerved utricles." In the hundreds of specimens which we have examined of the Alaskan *C. cryptocarpa*, we have invariably found the scales simply acute, and we failed to observe any deviation from the description of the perigynium. In regard to *C. filipendula*, of which we have examined material from Greenland and Iceland, we cannot but express our doubt as to the identity of this with *C. cryptocarpa*, and we are indeed much more inclined to consider it as a nearer ally of *C. salina*, an opinion that has already been pronounced by such critical students of the genus as Blytt and Boott. *C. Lyngbyei* is too characteristic a species to be confounded with any of the others and appears, thus, to be the only endemic species of the Færœ islands; and finally in regard to *C. capillipes* this is yet imperfectly known, but as long as some distinctive characters have been noted, especially in the perigynium, it would be safer to keep it as a distinct species until it is again studied and better known.*

Carex macrochæta C. A. Mey.

Although being exceedingly frequent on the Alaskan coast and the islands, the species shows but slight variation. The terminal spike is usually wholly staminate, but we found, however, a few specimens from Unalaska in which this was either androgynous or gynæcandrous or even entirely pistillate. Two quite striking varieties were noticed, viz:

var. *emarginata* nob.

Taller and more slender than the typical plant; spikes very long, loose-flowered, remote; scales of pistillate spike prominently emarginate with a seta four times as long as the body of the scale.

Alaska: Kukak Bay, collected by Messrs. Coville and Kearney.

* To give the reader some further idea of the treatment of the *Carices* in Flora Arctica, we might quote, for instance, the synonymy given of *Carex rotundata:* "*ambusta*," "*compacta*," "*membranacea*" and "*vesicaria γ alpigena*." Such errors are the inevitable result of compilation without access to authentic material and to the most important literature, the works of Boott for instance. It is, indeed, a pity to see the interesting Arctic plants submitted to so poor a treatment.

var. ***macrochlæna*** **nob.**

Very robust with four short and heavy pistillate spikes; perigynium very large and longer than the simply mucronate scale.

St. Paul Island, Bering Sea, collected by Mr. James M. Macoun.

Carex nesophila sp. n.

Rhizome stoloniferous with light brown, fibrillose, scale-like leaves; leaves shorter than the culm, relatively broad and flat, glabrous; culm very variable in height from 12 to 38^{cm}, erect, slightly bent near the apex, glabrous, phyllopodic; spikes from two to four,* the terminal staminate, the lateral pistillate or very seldom androgynous, contiguous, sessile and erect or the lowermost borne on exserted peduncles and, sometimes, nodding, all subtended by sheathless bracts with blades about as long as the inflorescence or shorter; scale of staminate flower elliptical, acute, deep purplish with three green midveins; scale of pistillate flower broadly elliptical, acute, purplish to almost black with faintly visible midrib of three veins; perigynium a little longer, but narrower than the scale, sessile, erect, from oval to elliptical oblong, few-nerved, pale green, the beak purplish, very short, entire or obliquely cut; stigmata three or, sometimes, two, the style not exserted.

St. Paul Island, Bering Sea: abundant on uplands with *Sieversia Rossii*, *Artemisia globularis* and *Potentilla villosa*, but not associated with any species of *Carex*, collected by Mr. James M. Macoun (Nos. 16,614 and 16); also on Popoff Island, Shumagin Islands, by Mr. T. Kincaid.

Carex nesophila resembles sometimes certain forms of *C. salina*, but the structure of the perigynium is always more like that of *C. macrochæta*, besides the spikes being contiguous. Although being a rather inconspicuous plant it has been collected in great numbers and only on the islands in Bering Sea, hence the name "*nesophila*."

Carex Schottii Dew. (figs. 10–11).

The species was originally founded on immature specimens from Santa Barbara, California, some of which are in the herbarium at Kew; Mr. Clarke has examined these and informed us that Bolander's specimens No. 1570, collected in swamps at Oakland and in salt-marshes near Fort Point, San Francisco, are identical with these; also identical with Bolander's plant

* As to the number of spikes we find in twenty-two specimens:
15 specimens with 3 lateral spikes.
5 " " 1 " "
2 " " 2 " "

is the so-called *C. obnupta* Bail., of which Mr. J. W. Congdon has sent us very fine material collected in swamps, Mendocino County, and they all answer the diagnosis of *C. Schottii* very well, but seem distinct from the little that we know of Dewey's *C. Barbaræ.* (Fig. 10 = scale of pistillate spike; fig. 11 = perigynium, both of *C. Schottii.*)

Carex magnifica Dew.

Through the kindness of Mr. Clarke we have learned that most of the specimens of so-called *C. Sitchensis* belong to this unpublished species of Dewey, who sent it to Boott. The real *C. Sitchensis* is a very different plant with slender and remote pistillate spikes, of which we have studied authentic material in the herbarium of Bischoff, which is now in the possession of the St. Louis botanical garden. This species, *C. Sitchensis* Prescott, is known from the coasts of Alaska and Oregon, and has been described as *C. Howellii* Bail.

Mr. Clarke, furthermore, states that Boott's plate 594 (*C. laciniata*), as to the plant depicted, represents *C. Sitchensis* Presc. *vera*, while the details are taken from the old, true *C. laciniata.* Identical with *C. Sitchensis* Presc. are, also, *C. cryptocarpa* Franch. and *C. atrata* Hook et Arn.

Carex lacunarum sp. n. (figs. 12–13).

Roots thick, very hairy; rhizome cæspitose with persisting, reddish brown leaf-sheaths; leaves as long as the culm, relatively narrow, carinate, glaucous and very scabrous; culm about 60^{cm} in height, coarse, triangular, scabrous, phyllopodic; spikes three to five,* the terminal and uppermost lateral staminate, the others pistillate or androgynous, more or less contiguous, sessile or the lower ones peduncled, nodding, cylindric, very dense-flowered, from 2 to 8^{cm} in length, subtended by bracts with blades longer than the inflorescence (fig. 12), sheathless or the lowest one with a short sheath; scale of staminate flower lanceolate, erosely denticulate above, three-nerved, pale purplish with hyaline margins and base: scale of pistillate flower (fig. 13) broadly ovate, acuminate, mucronate to aristate, erosely denticulate above, three-nerved, purplish brown with hyaline margins; perigynium (fig. 13) longer than the body of the scale, sessile or nearly so, erect, rhombic-oval, biconvex, coriaceous, two-nerved, slightly denticulate along the upper margins, otherwise glabrous, pale brown, the beak short, entire; stigmata two.

* As to the number of spikes, staminate and pistillate, we notice in:

7 specimens	2 staminate	spikes.
2 "	1 "	"
4 "	3 pistillate	"
5 "	2 "	"

California: Lagoon at Sebastopol, Sonoma County, collected by Mr. A. A. Heller (No. 5797), and in a marsh at Berkeley, collected by Mr. J. Burtt Davy. The species is nearest related to *C. magnifica* Dew., but is readily distinguished by the lighter color of the spikes and the very dense and regular arrangement of the pistillate flowers.

Carex siderosticta Hance.

We have placed this as a member of the *Lejochlænæ*, and it is interesting to see that in addition to the shape of the perigynium, the species agrees, also, by its monopodial rhizome and long-sheathed bracts, with the central forms: *C. laxiflora*, *Careyana*, etc. Otherwise the lateral spikes are all androgynous, a character which we do not think is sufficient for the segregation of the species from the *Carices genuinæ*.

It is somewhat remarkable that the rhizome is rather slender, creeping and stoloniferous, while most of the monopodial *Carices* have a short, cæspitose rhizome.

Carex cryptostachys Brongt.

As already stated by Boott, this must be referred to the *Dactylostachyæ*, and it possesses the same monopodial rhizome as is observable in *C. digitata* for instance; the structure of the perigynium is much the same, but the ramified culms with quite numerous, androgynous spikes, makes the species appear as the most evolute type of the section.

Carex physochlæna sp. n.

Rhizome loosely cæspitose with persisting purplish leaf-sheaths; leaves much shorter than the culm, very narrow, but flat, scabrous; culms from 30 to 42^{cm} in height, erect, slender, but stiff, trigonous, scabrous, only leafy at the base, phyllopodic; spikes two to three, the terminal staminate, the lateral pistillate, mostly contiguous, sessile, erect, very thick and dense-flowered, subtended by short, filiform, sheathless bracts, the lowest one spreading and about as long as the spike; scale of staminate flower obovate-oblong, obtuse, purplish with green midvein and pale margins; scale of pistillate flower ovate, obtuse, deep purplish to almost black with the midvein obsolete, shorter than the perigynium; perigynium sessile, spreading, oval to oblong, inflated, glabrous, faintly nerved, purplish above, yellowish below, the beak short, bidentate; stigmata three, the style flexuose within the perigynium.

Collected on Coal Creek hill, near the Yukon River, by Mr. Fr. Funston (No. 139).

Very distinct by the heavy, dark spikes contrasting the slender culm and narrow leaves: its nearest ally is *C. physocarpa*.

Brookland, D. C., October, 1903.

ART. XXVIII.—*Characters of Pteranodon (Second Paper)*; by G. F. EATON. (With Plates XIX and XX.)

BRIEF notices of some of the characters of *Pteranodon* Marsh were published in this Journal in July, 1903. A restoration of *Pteranodon longiceps* is now about to be installed at St. Louis, which has been prepared under my direction as the contribution of the Department of Vertebrate Paleontology of the Yale Museum to the University's exhibit at the Louisiana Purchase Exposition. It is therefore advisable to describe such additional characters of *Pteranodon* as are manifest in the restoration.

A half-tone engraving of this restoration appears as Plate XIX.

The Sclerotic Circle.

The sclerotic circle is composed of twelve thin plates of bone arranged with overlapping edges, so as to form a hollow truncate cone similar in shape to the avian sclerotic circle. Plate XX, figure 1, shows the arrangement of these plates in the left orbit of a large head of *Pteranodon*. By removing the matrix from under the left side of the skull, which was crushed laterally, the circle was exposed pressed inward against the interorbital septum and with the component plates little disturbed from their normal position.

Professor Williston* refers to the sclerotic circle of the allied genus *Nyctosaurus (Nyctodactylus)* in these words: "It had a ring of thin, large sclerotic plates, which were preserved in displaced positions. The separate plates were not united by imbrication, as in the mosasaurs." The chapter on the Pterosauria in the new edition of Zittel's Paleontology, 1902, as revised by Professor Williston, contains no description of this structure in either *Pteranodon* or *Nyctosaurus*. Oddly enough, in this revision, it is *Pteranodon* that is credited with a sclerotic circle, and not *Nyctosaurus* in which Professor Williston observed the structure.

The Vertebræ.

The most important note to be made here concerns the vertebral formula, which I have now determined. I have figured and described in this Journal (July, 1903) the series of vertebræ which are anchylosed together to support the ilia. Further investigation has shown the number of presacrals attributed to *Pteranodon* by previous writers to be incorrect. Instead of eight cervicals, as given by Professor Williston, there are in reality nine. In the dorsal series are included

* Journal of Geology, vol. x, p. 528, 1902.

eight vertebræ anchylosed to form the notarium, and four free dorsals intervening between the notarium and the sacrum.

Professor Williston has been at considerable pains to demonstrate the number of cervical vertebræ in *Pteranodon* and *Nyctosaurus*, and it is from him I quote:* "If, however, we consider that vertebra which bears the first rib articulating with the sternum to be the first dorsal, then I believe that the prevailing number of cervicals in pterodactyls is eight.

. . . .

"From the foregoing, then, it seems assured that there is a free, short vertebra in front of the notarium, in both *Pteranodon* and *Nyctosaurus*, bearing a free, small rib, which does not unite with the sternum. This vertebra is the eighth cervical, and is probably present in all pterodactyls."

Following the atlas and axis are five vertebræ with long centra, then two vertebræ with short centra, making nine cervicals in all. Plate XX, figures 2, 3, and 4, show the seventh, eighth, and ninth vertebræ in their correct sequence, the longest of the three being the seventh. As there is no doubt that the seventh is the most posterior of the long-bodied cervicals, it is here only necessary to illustrate and call attention to the last three cervicals, and to state that they were preserved in their normal arrangement and that the ninth was in contact with the first true dorsal or notarial vertebra, i. e., the first vertebra connected by ribs with the sternum. I hope to show later that Professor Williston is right in supposing that *Pteranodon* and *Nyctosaurus* have the same cervical formula. The number of cervicals in *Pteranodon*, however, is nine, and not eight as formerly supposed. Fortunately, the material in the Yale University Museum satisfactorily decides this mooted question.

In describing the specimen of *Nyctosaurus* upon which Professor Williston bases his calculation of cervical vertebræ (Osteology of Nyctosaurus), he says that the eighth cervical lay "close to the first notarial vertebra, and near the presternal process of the sacrum," from which statement I must suppose his evidence less satisfactory than my own.

The four free dorsals which follow the notarium are shown in their normal sequence in figures 5, 6, 7, and 8, of Plate XX. Unlike the eight notarial vertebræ, these four were probably capable of slight motion. This is indicated by the character of the articular facets of the zygapophyses and of the ends of the centra. The figures correctly show transverse processes terminating in facets for the support of single-headed ribs. Like all the vertebræ in the entire vertebral column, so far as observed, these four free dorsals are procœlous.

* On the Osteology of Nyctosaurus, Field Columbian Museum, Publication 78, pp. 127, 129, June 1, 1903.

By assuming that the first four vertebræ of the sacral series (in the broader sense) are homologues of the lumbars of other groups, the total number of presacral vertebræ would appear to be twenty-five. This compares closely with the supposed number of presacrals in the Eusuchia.

Paleontological Laboratory,
Yale University Museum, February 29, 1904.

EXPLANATION OF PLATES.

PLATE XIX.

FIGURE 1.—Restoration of *Pteranodon longiceps* Marsh; prepared from the original fossil bones, by H. Gibb, under the direction of G. F. Eaton, at the Yale University Museum, March, 1904. One twenty-fourth natural size.

PLATE XX.

FIGURE 1.—Left orbit and sclerotic circle of *Pteranodon*. The arrow points to the anterior extremity of the head.
FIGURE 2.—Seventh cervical vertebra of *Pteranodon*.
FIGURE 3.—Eighth cervical vertebra of *Pteranodon*.
FIGURE 4.—Ninth cervical vertebra of *Pteranodon*.
FIGURE 5.—Ninth dorsal vertebra of *Pteranodon*.
FIGURE 6.—Tenth dorsal vertebra of *Pteranodon*.
FIGURE 7.—Eleventh dorsal vertebra of *Pteranodon*.
FIGURE 8.—Twelfth dorsal vertebra of *Pteranodon*.

All the figures are three-fourths natural size, and illustrate the left side of the specimens.

ART. XXIX. — *Palæontological Evidence for the Original Tritubercular Theory;* by HENRY F. OSBORN. (With Plate XXI.)

THERE has been a strong reaction of late against the original tritubercular theory so far as it concerns the origin of the upper molar teeth of mammals, by embryologists, comparative anatomists and palæontologists. Among the latter, Dr. J. L. Wortman has reached especially strong conclusions, which have been published in this Journal.*

According to the original theory of Cope as developed by Osborn, the homologue of the main reptilian cone or protocone is invariably situated on the antero-internal, or lingual side in the upper teeth.

According to the views of the earlier opponents of the tritubercular theory, the protocone is found on the antero-external side, as in the premolars, and corresponds with the cusps which Osborn called the paracone. According to the views of M. F. Woodward,† which were based on embryology, the protocone varies in position in different groups of mammals, namely, antero-internal in certain zalambdodont insectivores (Centetes), and antero-external in Dilambdodonta (Erinaceus), as well as in most other mammals. Similarly Wortman, by analogy with the premolars (this Journal, November, 1903), believes that the position of the protocone may have been variable, that is, in some cases internal, in others external.

The whole point of this very complex question turns on the simple question of evidence whether the main reptilian cone, or *protocone*, of the ancestors of mammals was found upon the antero-internal side or on the antero-external side of the upper molars.

The original evidence upon which Osborn supported and developed Cope's theory is that derived from the rare upper molar teeth of the Jurassic mammals. Osborn‡ cited (1) the upper teeth of *Triconodon*, in which the main cone is *central*, (2) the upper teeth of *Peralestes* (British Museum) fig. 2, in which the main cone is *internal*, (3) the upper teeth of *Kur-*

* "In view of the facts above set forth, however, I am more firmly than ever of the opinion, that all such attempts [to name the cusps of the molars in accordance with their supposed homologies, rather than with their relative positions] are foredoomed to failure, and I believe they should be abandoned as utterly useless and confusing; that of Professor Osborn, being doubly erroneous, is therefore the most open to objection in this regard." (This Journal, vol. xvi, November, 1903, p. 368.)

† Proc. Zool. Soc., Lond., 1896, pp. 557–594.

‡ On the Structure and Classification of the Mesozoic Mammalia. Jour. Acad. Nat. Sci., Phila. (2), ix, pp. 242–246.

todon, fig. 3, in the British Museum in which the main cone is *internal*, (4) a reference by Professor Marsh to the fact that in the upper molars of *Dryolestes* the main cone is *internal*. In each case the main cone was believed to be the protocone.

The teeth last mentioned (4) were not personally examined at the time, but through the kindness of the late Professor Charles E. Beecher I was recently enabled to study them in the Yale University Museum.

The specimens consist of two superior series. They both show that the large, single, main cusp of the crown is *internal*, and in my opinion they present *conclusive evidence of the truth of the tritubercular theory as originally proposed*.

More in detail, the two specimens taken together show perfectly the structure of both the crowns and fangs of seven superior molar teeth, and confirm entirely the general description given by Marsh, to which some important points may be added as follows:

(1) The molars are sharply distinguished from the premolars, which are bifanged teeth with simple, laterally compressed crowns. (2) The molar crowns are broadly transverse or triangular, and upon the *internal* side of each is a large, conical, pointed cusp, *pr*, supported by a large, stout fang, fig. 1 A, *m6*, *m7*; around the inner side of each of these cusps is a delicate cingulum, fig. 1 A, *c*. (3) The *external* portion of the broadly triangular crown is supported on two smaller fangs, fig. 1 A, *m6*, *m7*. (4) The external portion of the crown is depressed, and bears one large antero-external cusp *?pa* and one smaller postero-external cusp *?me* which is either partly worn away or less pronounced in development. (5) Outside of this external wall there is also a faint basal cingulum, *c*, *c*, *c*. (6) Connecting these low external cusps with the elevated internal cusp are two transverse ridges; the anterior transverse ridge is higher and stronger than the posterior.

These features are clearly shown in the accompanying drawings, fig. 1, which were made and shaded under the camera lucida and therefore admit of no doubt as to interpretation.

These two specimens fully supplement and confirm each other; they also supplement the evidence derived from the study of the superior molar teeth of *Peralestes* (fig. 2) and of *Kurtodon* (fig. 3) in the British Museum, which were cited and figured in my memoir and in various subsequent papers on trituberculy.

Again summing up this combined evidence, we find in the Jurassic period the superior molars of the only mammals known (excepting the Triconodonta and Multituberculata) to consist of a large conical internal cusp or *protocone*, which we

have every reason to believe is homologous with the large external cusp or *protoconid* in the lower jaw.

Secondly, that the external cusps in the superior molars are depressed and comparatively small, consisting of two, more or less well-defined cusps. Thirdly, that this palæontological evidence lends no support, either in crown or fang structure, to the evidence of embryology that the paracone (*?pa*, or antero-external cusp) is the oldest cusp. Fourthly, that it lends no support to the premolar-analogy theory, which was originally suggested by Huxley* in his description of the teeth of the Canidæ in 1880, which has been supported by Scott and other palæontologists, and finally set forth with fresh arguments by Dr. Wortman; this 'premolar-analogy' theory is to the effect that the key to the past evolution of the molar teeth is to be found in the subsequent or present evolution of the premolar teeth, and that thus in many groups of animals at least the protocone occupies the same position in the upper molars as in the upper premolars. Fifthly, that all the known Upper Cretaceous mammals with triangular molars accord with the Upper Jurassic mammals in exhibiting the antero-internal cone as the main cone. Finally, that no such variations of structure are observed in the upper molars of the most primitive mammals as would be the case if there had been different modes of origin of the triangular or tritubercular crown.

In a succeeding article I shall take up and discuss some of the other points and theories raised in Dr. Wortman's interesting and important papers.

EXPLANATION OF PLATE XXI.

Figure 1.—Superior molars of *Dryolestes* Marsh. *A.* Series of the left side, external and crown views. *B.* Series of the right side, external, crown and internal views. Yale Museum.
pr, pr, pr, main internal cusps believed to be protocones.
?pa, ?me, smaller external cusps believed to be para- and metacones.
c, c, c, external and internal cingula.
i. o. f. infraorbital foramen.

Figure 2.—Superior molars of *Peralestes* Owen. Right side. External, oblique and crown views. British Museum.
mts, metastyle. Other abbreviations as in fig. 1.

Figure 3.—Superior molars of *Kurtodon* Osborn. Left side. British Museum.

* Collected Memoirs, vol. iv, p. 450.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *Gases Occluded or Evolved by Radium Bromide.*—Dewar and Curie describe some experiments made with 0·4^{g} of radium bromide. The pure, dry salt was placed in a glass tube communicating with a small Geissler tube and a mercury manometer, and a very perfect vacuum was produced in the apparatus. During three months gas was given off at the rate of 1^{cc} per month, and an examination of the spectrum by means of the Geissler tube showed only the presence of hydrogen and the vapor of mercury. It is possible that a minute quantity of moisture was introduced with the salt, and that this was gradually decomposed under the influence of radium.

The sample of radium bromide was then taken to England in order to make other experiments with it, and there it was transferred to a vessel of fused quartz, where it was heated to fusion at a red heat after the air had been exhausted by means of a mercury pump. The gases given off in this operation were passed through three U-tubes cooled with liquid air, which retained the greater part of the radium emanation and the less volatile gases. The more volatile gases collected in this way amounted to 2·6^{cc}; they had carried with them some of the emanation and were radio-active and luminous. Dewar examined the spectrum of this spontaneous light by means of a photographic spectroscope with a quartz prism and an exposure of three days, with the result that three bands belonging to nitrogen were obtained. When the gas was subjected to the electric discharge in a Geissler tube, the spectroscopic bands of nitrogen were also obtained, and upon condensing the nitrogen by exposure to the temperature of liquid hydrogen a high vacuum was produced in the Geissler tube, and the spark then indicated the presence of nitrogen, but nothing else.

The quartz tube containing the radium bromide which had been fused and thus freed from occluded gases was then sealed while exhausted, by means of the oxyhydrogen blowpipe, and taken back to Paris. Then, twenty days after it had been sealed, Deslandres illuminated the interior of the tube by a Ruhmkorff coil by the aid of small coatings of tin-foil applied to the exterior of the ends of the tube, and obtained the complete spectrum of helium, with no other lines, by means of a photographic spectroscope with a quartz prism. This result agrees with those of Ramsay upon the production of helium by radium salts dissolved in water, and it is interesting in showing that the presence of water is apparently unnecessary for this production of helium.—*Comptes Rendus*, cxxxviii, 910. H. L. W.

2. *Uranyl Double Salts.*—Rimbach, Bürger and Grewe have prepared a large number of these double salts, many of which

are new, and have studied their solubility in and decomposition by water. It was found that a large number of double chlorides, bromides, and sulphates correspond to the type $UO_2X_2'\cdot 2XX'$, while the double nitrates, chromates, and fatty-acid salts belong to the type $UO_2X_2'\cdot XX'$, where X signifies an atom of a univalent metal, and X′ a valency of a negative atom or radical. There are also exceptional types, such as $UO_2X_2'\cdot 4XX'$.

The stability of the double salts with water was found by analyzing saturated solutions of them prepared at different temperatures. When the ratios of the constituents in solution did not agree with the composition of the original compound, decomposition by water was shown. It was found that all the double nitrates are thus decomposed at the lower temperatures experimented with, while the double chlorides are more stable, and those containing alkali-metals of higher atomic weights (Rb and Cs), or complex radicals of strongly basic character, are not decomposed at the observed temperatures. The alkali-metal double sulphates are also stable, except when they form salts of the type $UO_2X_2'\cdot 4XX'$, which are extensively decomposed by water. All of the salts decomposed by water were found to become stable at higher temperatures, usually at about 60 or 80°. —*Berichte*, xxxvii, 461. H. L. W.

3. *The Presence of Formic Aldehyde in the Atmospheric Air.* —In the course of researches upon the atmospheric air, H. HENRIET has detected the existence in it of a gaseous substance, other than formic acid, possessing energetic reducing action, and capable of reducing Fehling's solution and of decolorizing iodide of starch. In order to study this compound and to determine its identity, he examined rain-water which came from fogs. The samples of water, after filtration, were concentrated slowly upon the water bath from a volume of 30 or 40^{l} to about 200^{cc}. The samples were neutral at first, but became acid upon concentration, and deposited a certain quantity of calcium sulphate which was removed by filtration. The products which were strongly colored, with an orange-yellow tint, were subjected to simple distillation, and the distillates contained formic acid and a reducing agent which distilled in the presence of acids or alkalies, and gave the general reactions for aldehydes as well as special reactions for formic aldehyde.

The author concludes that formic aldehyde exists in the air, and that this substance, which is a powerful antiseptic, plays an important rôle in connection with the purity of the air.—*Comptes Rendus*, cxxxviii, 203. H. L. W.

4. *Revision of the Atomic Weight of Iron.* — About four years ago Richards and Baxter, by the reduction of ferric oxide by hydrogen, obtained the value 55·883 (O = 16·000) for the atomic weight under consideration. BAXTER has recently made further determinations of this atomic weight by comparison of carefully purified and sublimed ferrous bromide with the silver bromide produced by it, or, in other cases, the silver required to

react with it. The average result, after all corrections had been made, was 55·870, a remarkably close agreement with the result of the other method.

In connection with this work the effect of the earth's magnetism upon the weight of magnetic substances has been discussed, and it has been shown by experiment to be entirely inappreciable.—*Zeitschr. Anorgan. Chem.*, xxxviii, 232. H. L. W.

5. *Method of Separating Iron and Aluminium.*—A method for making this analytical separation by boiling in the presence of an excess of sodium thiosulphate has been suggested by Chancel, but it has not been found satisfactory. LECLÈRE has modified the method by first adding ammonium thiosulphate to the very dilute solution containing a slight excess of sulphuric acid. This reduces the iron to the ferrous condition. Then a large excess of ammonium formate is added, and the aluminium is precipitated by boiling, in the state of basic formate. In drying the precipitate it is advisable to treat it with nitric acid, in order to destroy formic acid and prevent the presence of a residue of carbon in the ignited alumina. The iron can be precipitated in the filtrate as sulphide.—*Comptes Rendus*, cxxxviii, 146. H. L. W.

6. *Phosphorescence.*—ALBERT DAHMS gives an historical summary of the results of Seebeck and of Becquerel; and takes up the study of the phenomena discovered by them with the additional aid of photography. A number of interesting photographs accompany the paper. The various substances were exposed to the light of the carbons of an electric arc, and the photographs show carbon bands in the blue portion of the spectrum, and also in some cases bands in the extreme infra-red. The author shows that the phenomena are conditioned not only by the relative velocities of the rays, but also by the amount of energy contributed to the phosphorescent substances, and also by the inherent energy of such substances.—*Ann. der Physik*, No. 3, 1904, pp. 425–463. J. T.

7. *Preliminary Measurements of the Short Wave Lengths discovered by Schumann.*—For the past few years Dr. Theodore Lyman has been engaged in the Jefferson Physical Laboratory in an attempt to measure the short wave lengths discovered by Dr. Victor Schumann; but it is only recently that this attempt has proved successful.

Working in an atmosphere of hydrogen with a concave grating ruled upon speculum metal, an end-on tube filled with hydrogen gives numerous lines below the aluminum group at 1854. The shortest wave length so far observed has a value 1178 Ångström units. The limit of error is two units.

It is interesting to note that, contrary to expectation, speculum metal is able to reflect these very short wave lengths to a considerable degree. This is merely a preliminary notice. The author has in preparation a complete list of these new wave lengths; and he has good hopes of still further extending the spectrum. It is

his purpose to publish a detailed account of the investigation in the Proceedings of the American Academy and perhaps elsewhere.

J. T.

8. *Heating effect of the Radium Emanation.* — It has been shown that the radiation emitted from a radium compound in a state of radio-active equilibrium may be divided into three parts:

(1) A non separable radiation consisting entirely of α rays; and constituting about 25 per cent of the total radiation.

(2) The radiation from the emanation occluded in the radium, also consisting entirely of α rays.

(3) The excited radiation produced in the mass of the radium, consisting of α, β, and γ rays.

(2) and (3) together constitute about 75 per cent of the total radiation.

It is found that the emanation supplies 18 per cent, the non-separable activity 25 per cent, and the excited activity 57 per cent of the total activity of radium. On heating or dissolving a radium compound in an open vessel, the emanation is released and can be entirely removed by a current of air. The excited activity, or emanation X, is non-volatile, and being left in the radium immediately begins to decay. Since fresh emanation is being constantly produced by the radium and occluded in it, the activity of the radium after falling to a minimum gradually rises again, and in the course of a month nearly reaches its original constant value. Interesting curves are given of the energy of the various forms of activity; and calculations of the amount of heat from the emanation. It is computed that the amount of heat liberated per hour from 1^{cc} of the emanation lies between $1{\cdot}25 \times 10^{6}$ and $1{\cdot}25 \times 10^{6}$ gram-calories. This amount of heat would probably be sufficient to raise to a red heat, if not to melt down, the glass tube containing it. One pound weight of the emanation would initially radiate energy at the rate of 10^{4} to 10^{5} horse-power, and while the heating continued would emit an amount of energy between 6×10^{4} and 6×10^{5} horse power days. According to the author's disintegration hypothesis, this energy is derived from the energy latent in the radium atoms and is released in the various stages of their disintegration. — *Rutherford and Barnes in Phil. Mag.*, Feb., 1904, pp. 202–219.

J. T.

9. *Nature of the Emanations from Radium.*—Lord KELVIN finds it difficult to believe in the atomic disintegration hypothesis of Rutherford, and suggests that radium may transform etheric vibrations into its peculiar manifestations of energy, just as a black cloth in a test tube filled with water shows an increase of heat over a similar receptacle filled with water and containing a piece of white cloth.—*Phil. Mag.*, Feb., 1904, pp. 220–222.

J. T.

II. Geology and Natural History.

1. *United States Geological Survey.* — The following folios have recently been published:

No. 97. Parker folio, South Dakota; by J. E. Todd.

No. 99. Mitchell folio, South Dakota; by J. E. Todd.

No. 100. Alexandria Folio, South Dakota; by J. E. Todd and C. M. Hall.

Four connecting folios dealing with the James River region have thus far been published and they show clearly the unity of this geologic province. Sioux quartzite (Algonkian) underlies the region and constitutes the "bed rock" of the well drillers. The Paleozoic, Triassic and Jurassic are absent, and the Cretaceous is represented by the Colorado Group (Benton and Niobrara). Rock outcrops are exceedingly rare and the distribution and characters of the pre-glacial formations is determined in large measure from the numerous artesian well records.

The whole area is practically a plain of till diversified by a series of moraines left by the retreating glacial lobe. The till is from 10 to 350 ft. deep and appears to belong entirely to the Wisconsin epoch. No complicated drainage modifications are apparent, and, in fact, the area exhibits simple geologic structure in every respect. These three folios together with the Olivet (No. 96), are particularly valuable for their descriptions of glaciation and artesian water conditions.

No. 98. Tishomingo folio, Indian Territory; by Joseph A. Taff. The Tishomingo quadrangle exhibits two types of topography; a Cretaceous peneplain composed of Paleozoic formations, and a dissected plain of Cretaceous strata. In addition to the Cretaceous, Cambrian, Silurian, Devonian, and Carboniferous strata are represented. A pre-Cambrian granite occupies a considerable area and with it are associated a quartz-monzonite and numerous dikes of diabase, diorite and aplite intruded at different times. A commendable feature of the folio is the publication of lists of fossils with each formation and the attention given to correlation. The Arbuckle uplift, occupying the northern half of the quadrangle, is composed of a number of folds, constituting a broad arch. The synclines are faulted to an extraordinary degree, the main faults being approximately parallel with the folds. "The folds are open and never overturned" . . . "and the faulting, in most cases at least, is of the normal type or drop faulting." Asphaltic deposits of economic importance occur in the Ordovician sandstone and limestone, and to less extent in the Carboniferous limestone conglomerate.

2. *Glacial Geology of Tasmania*; by J. Walter Gregory. Quart. Jour. Geol. Soc., lx, 37.—The existence of Carboniferous glacial beds in Tasmania has long been known, and in 1894 E. J. Dunn furnished the first conclusive evidence of Pleistocene glacial action, after an examination of the summits of the Western Highlands. Prof. Gregory now shows that, contrary to the view

held by most observers of that region, there has been widespread glaciation in Tasmania down at least to the 400 ft. level. These low level deposits are best preserved in the valleys of the King, the Linda and the Pieman River.

3. *Report on a Geological Reconnoissance of the Iron Region of Angat, Bulacan;* by H. D. McCaskey. 62 pp., 56 pls. Bull. 3, Mining Bureau Phillippine Islands.—A sketch of the Geology of the Province of Bulacan shows many interesting features. The rocks described are pre-Tertiary crystallines (diorites?), modern volcanics, Tertiary or early Quaternary sedimentary rocks, tuff deposits, alluvium. One fossil found is of early Mesozoic or late Paleozoic age. The photographs, tables of analyses and maps are valuable additions to the text.

4. *Mineral Tables for the Determination of Minerals by their Physical Properties*; by Arthur S. Eakle. Pp. 73. New York, 1904 (John Wiley & Sons).—Mineral tables, based upon physical properties, have the advantage as compared with those which are strictly chemical, that they call the attention of the student to the visible characters of the specimens he is handling, and hence tend to increase his knowledge of them. The Weisbach tables have been long and favorably known, but this volume now issued differs from them, in that the fundamental basis of classification is that of *color.* The arrangement is based, first, on the color of the fine powder, the *streak*, and second upon the color of the mass. The individual species, with their other characters given in tabular form, are arranged by their specific gravities. The tables have evidently been carefully prepared, and under the guidance of a good teacher should give excellent results.

5. *Meteorite Catalogues.* — The catalogue of the Collection of Meteorites of the Field Columbian Museum in Chicago, compiled by Dr. O. C. Farrington, has recently been issued. It shows that the collection has grown from the 179 falls in July 15, 1895, to 251 falls in May 1, 1903, and the total weight from 2,099 to 2,289 kilograms. The collection has large masses of the following: Brenham 445 kgs., Canyon Diablo 690 kgs., Long Island 528 kgs., Toluca 177 kgs.

A catalogue of the collection of the Berlin University, by Prof. C. Klein, has also appeared. This collection is now one of the largest in the world in number of falls, the total number amounting to 450. The latest estimate (quoted by Klein) for the Vienna collection gives 560 localities in 1903, for London 476 in 1896, for Paris 466 in 1898. In addition to the classified list of meteorites, this catalogue also contains more or less detailed descriptions of several meteorites. A point of unusual interest is the identification of the mineral *leucite* which is present in minute trapezohedrons in the Schafstädt meteorite (1861) with anorthite, augite, etc.; it is probably also present in the Pawlowka (1882) meteorite.

6. *The Fauna and Geography of the Maldive and Laccadive Archipelagoes;* edited by J. Stanley Gardiner. Vol. II, Part

II, pp. 589–698, with text figures and 12 pls. (See this Journal, xiii, 321; xiv, 74; xv, 240, 488; xvi, 400.)—Mr. E. A. Smith, in his report on the "Marine Mollusca" of the expedition, mentions that this collection is of special interest, as being the first of any importance ever studied, from this region. Among the 380 species found, probably all of the more conspicuous forms which actually occur there are represented, only the more obscure or smaller ones having been overlooked. Although the fauna is similar to that of the islands of the Indian Ocean, it is curious that the larger proportion of the species have been previously noted from the China Seas eastward and in the Pacific. Many common widely distributed species are represented, although certain genera which occur in the surrounding seas do not appear. About three-quarters of the species are known to exist in the seas surrounding the Philippine Islands and Malay Archipelago and farther north; about one-quarter are similar to those from Japan. Twenty-two species are described as new, most of which are well figured.

Mr. R. A. Punnett reports the collection of "Enteropneusta," in numbers and variety of forms, to be the most extensive ever made. Seven species and one genus (*Willeyia*) are described as new and the genus *Ptychodera* is for the first time thoroughly studied.

Mr. L. A. Borradaile continues his extensive studies of the "Marine Crustaceans;" his report on the "The Spider-crabs (*Oxyrhyncha*)" being his tenth contribution. Of the twenty-nine species recorded, three are described as new. "The Classification and Genealogy of the Reptant Decapods" is also given.

K. J. B.

7. *North American Fauna, No. 23, Index Generum Mammalium:* A list of the genera and Families of Mammals by T. S. Palmer, Assistant Biological Survey. Prepared under the direction of Dr. C. Hart Merriam, Chief of Division of Biological Survey. Pp. 984. Washington, 1904.—Of the three parts of which this comprehensive work consists, part 1 (pp. 7–718), giving an annotated list of the generic names of mammals, was begun in 1884 by Dr. Merriam and completed by Dr. Palmer. Parts 2 and 3 have been prepared by Dr. Palmer alone; they give (2) an alphabetical list of families of mammals (pp. 719–776) and (3) a classified list of the generic names arranged by orders and families (pp. 777–984).

III. Miscellaneous Scientific Intelligence.

1. *Christian Faith in an Age of Science;* by William North Rice. Pp. 425, New York, 1903 (A. C. Armstrong & Son).—The question to which an answer is offered in this most interesting volume is, "Can the faith which first breathed in the unscientific atmosphere of the first century survive in the scientific atmosphere of the twentieth century?"

The great value of the book lies in the fact that the author combines in his own personality the highest training, knowledge and practical comprehension of modern science with a profound and reverent Christian faith.

In the first part a general survey of the progress of human knowledge is presented, precise and exact in its criticism. It is shown how step by step the crude fancies of a timid, ignorant and superstitious people have been replaced by the exact and demonstrated facts and laws of science:—a flat world, with the mountain pillars supporting the roof of heaven, has become a globe whirling free in space; geocentric astronomy, the seven days of creation, miracles, spontaneous generation and a carpenter idea of, and an interfering God, have become the heliocentric solar system, the illimitable spaces of the universe, the millions of years of geologic time, the orderly evolution of worlds, of the structure of the earth and of organisms, the conservation of energy and the unerring sequence of cause and effect. These advances of knowledge have seemed to take away the very foundation upon which the old systems of theology rest.

In the second part, with the same calm, scientific method, the author shows how religious ideas have become clarified and their essential truths brought out more distinctly, as the world has advanced. We find in his terse, but sufficiently full, portrayal of the modern conceptions of the personality of man and of God, the scientific conception of providence, of prayer and the nature and meaning of the bible, an admirable and sufficient answer to his original question.

The conclusion reached is that, although, as in science "certainty in natural science is demonstrated to be absolutely unattainable;" so "no claim of certainty can be maintained in regard to Christianity as a system or in regard to any particular doctrine of Christianity." Nevertheless, it is a fact, that, "The generation in which we live—the generation which has accepted the doctrines of modern science—is more strongly influenced by the teachings of Christianity than any previous generation, and multitudes of men and women find that the acceptance of scientific teachings in no wise disturbs their personal religious life," and "our partial knowledge justifies the prophetic hope that no scientific discovery will contradict the essence of Christianity, and that the end of all questioning will be the reëstablishment of faith." H. S. W.

2. *Beiträge zur chemischen Physiologie;* herausgegeben von F. HOFMEISTER. IV. Band, 9–12; Braunschweig, 1903 (Vieweg u. Sohn).—The closing parts of this volume contain a number of important papers among the fifteen contributions. These include extensive studies on the occurrence of albumoses in the blood, by O. Schumm; two papers on glycolytic ferments; an elaborate investigation of the antecedents of the fibrin ferment, by Morawitz; and several contributions pertaining to the chemistry of the proteids. The possibility of transforming albumins into globulins is emphasized in detail by L. Moll; and Embden and v. Fürth have demonstrated that the rapid disappearance of typ-

ical effects after suprarenin (adrenalin) injections is not due to any rapid oxidation of this compound in the body, but rather to its gradual dilution by diffusion and distribution in the organism.

L. B. M.

3. *Astronomical Observatory of Harvard College*, Edward C. Pickering, Director.—Recent publications are the following:

Annals, Vol. XLIII, part iii. Observations and Investigations made at the Blue Hill Meteorological Observatory in the years 1901, 1902, under the direction of A. Lawrence Rotch; with appendices containing a discussion of the effect of meteorological conditions upon audibility; also the observations with kites, 1897–1902, and a description of the kites and instruments. Pp. 115–239, with four plates.

Annals, Vol. XLVIII, No. ix, Geographical Position of the Arequipa Station, by Winslow Upton, pp. 221–273.

Circular, No. 74. Variable Stars of long Period, pp. 10. No. 75, Variability of Iris (7).

4. *Publications of the United States Naval Observatory*, Rear-Admiral Colby M. Chester, U. S. N., Superintendent. Second Series, Volume V. *Meteorological Observations and Results, 1893–1902.* Pp. x, 443, 4to. Washington, 1903.—This volume contains the usual meteorological observations, given in tabular form, of barometric pressure, temperature, wind direction and velocity, etc., taken at the Naval Observatory, Georgetown Heights, during the decade from 1893 to 1902.

5. *Where did Life Begin?* by G. Hilton Scribner. 75 pp. New York, 1903. (Charles Scribners' Sons.)—In 1883 Mr. Scribner published a monograph advocating the theory that living forms originated within the circumpolar area. This book is now republished, and it is worthy of note that the "Scribnerian theory of the Place of the Origin of Life" is in accord with the conclusions reached by Dr. J. L. Wortman from a study of vertebrate fossils and by Dr. Wieland from a study of fossil plants (this Journal, xv, 419; xvi, 401).

6. *Field Columbian Museum.* — Among the recent publications is to be mentioned Vol. IV of the Anthropological Series by George A. Dorsey (pp. xii, 228, with 139 plates), giving a minute and fully illustrated description of the famous Arapaho Sun Dance. Other publications are the following: On the Osteology of *Nyctosaurus* (Nyctodactylus) with notes on American Pterosaurs by S. W. Williston. Structure and Relationship of Opisthocœlian Dinosaurs, Part 1, *Apatosaurus* Marsh; by E. S. Riggs. Catalogue of Meteorites by O. C. Farrington, mentioned on p. 329.

7. *Bureau of American Ethnology: Twentieth Annual Report to the Secretary of the Smithsonian Institution, 1898–99;* by J. W. Powell, Director. Washington, 1903.—This volume contains the report of the Director (pp. i–ccxxiv) and also an interesting paper by W. H. Holmes (pp. 1–237) giving a description of the aboriginal pottery of the eastern United States, illustrated by a hundred and seventy-seven plates and seventy-nine text figures.

THE

AMERICAN JOURNAL OF SCIENCE

[FOURTH SERIES.]

ART. XXX.—*Recent Changes in the Elevation of Land and Sea in the Vicinity of New York City*; by GEORGE W. TUTTLE.

THE late Professor George H. Cook, long identified with the Geological Survey of New Jersey, read an important paper at the Montreal meeting of the American Association for the Advancement of Science, August 13th, 1857, "On the subsidence of the land on the seacoast of New Jersey and Long Island,"* in which he stated that "an attentive examination of these facts has led me to the conclusion that a gradual subsidence of the land is now in progress throughout the whole length of New Jersey and Long Island, and from information derived from others I am inclined to think that this subsidence may extend along a considerable portion of the Atlantic coast of the United States."

The evidence on which Professor Cook based this conclusion was mainly of a geologic nature, and consisted of, 1st, submerged forests and buried timber found in the marshes and along the coast below tide level; 2d, numerous Indian shell heaps which have been found below tide level; 3d, the extension of the marsh on the upland, verified by many old residents, and by the dying out of cedar trees on the margin; 4th, less fall of water at any stage of the tide available to operate the waterwheels of mills on tidal streams near the sea.

It was the opinion of a number of mill operators, that within their memory the loss of head available to operate their wheels was of such an amount as would denote the sinking of the land at the rate of two feet per century. Besides, sluices in banks protecting meadow land, built about 150 years ago, were found three feet below tide level and useless for their intended purpose.

Professor Cook's estimate of the amount of subsidence of the

* This Journal, 2d Series, xxiv, 1857, p. 341.

land, which has been quoted by many authorities, rests on the above evidence, and is manifestly open to doubt and uncertainty, as he recognized when he wrote in his 1885 report, that "we find conclusive evidence of a general subsidence of the coast, or rise of water level to an extent of from ten to twenty feet within a short period of geologic time, but at a rate which is not quite definitely established." Professor Cook furthermore stated in his report of the Geology of New Jersey in 1868, that "this movement is one of a series which has occurred on our coast by which the line of water level has been alternately elevated and depressed, the whole range being confined within twenty feet."

Others have since frequently expressed the same ideas, but as they probably made use to a large extent of Professor Cook's opinions and evidence, it will be needless to quote them.

The self-registering tide gauge had only recently been made use of when Professor Cook read his paper, and tidal observations could not be obtained to determine the rate of subsidence, but since that date long series of tidal observations have become available, and it is proposed to develop in this paper what such observations in New York Harbor can tell as to the relative changes in the elevation of earth and sea in the vicinity.

The tidal observations at New York, which are of importance, start from the year 1853, when a self-registering tide gauge was put in operation by the Coast Survey at Governor's Island, and maintained up to and including the year 1879, when the series terminated. We also have the records of a self-registering gauge maintained by the Coast and Geodetic Survey during the years 1876–92, at Sandy Hook, N. J., records of self-registering gauges of the Department of Docks and Ferries from 1888–1903, at Pier A, West 57th St., and from 1894–1903 at East 24th st., in New York City, besides the record from a self-registering tide gauge of the Coast and Geodetic Survey at Fort Hamilton, for the years 1893–1902.*

The observations at Governor's Island were all referred to B. $M._1$,† which was established about the year 1853 by the Coast Survey and is still in existence. Levels were run from this bench mark to other benches, in 1875 and again in 1886. The differences found at those times were checked in 1898 and 1900 and found correct, so that we may be confident that since 1875 B. $M._1$ has not settled or been otherwise disturbed.

The datum plane used in this paper is mean low water—

* The writer is indebted to the U. S. Coast and Geodetic Survey and to the Department of Docks and Ferries, New York City, for tidal data not hitherto published.

† For description see C. and G. S. Report 1887, app. 14, p. 293.
" " 1899, app. 8, p. 555.

M. L. W.—at the Battery as used by the Department of Docks and Ferries which is known as Battery datum, and is 2·186 feet below the datum plane of the Coast and Geodetic Survey in their levelling operations in the vicinity of New York City.*

The elevation of B. M.[1] from the above Coast and Geodetic Survey levels is 14·203 feet, and from ordinary levels run directly from the Battery to Governor's Island the elevation 14·160 was obtained. We shall adopt the former value in the succeeding work.

The following is the record of the observations at Governor's Island for each year.

Year.	Half tide level above zero of staff.	Half tide level above Battery datum.	
1846	8·32 ft.	....	
1847	10·31	....	
1848	13·12	....	
1849	12·92	....	
1850	14·16	....	
1851	12·20	....	
1852	10·51	....	
1853	5·30	1·920 ft.	
1854	5·07	1·690	
1855	5·32	1·940	
1856	7·507	1·778	
1857	7·640	1·911	
1858	7·591	1·862	
1859	7·616	1·887	
1860	7·575	1·846	
1861	6·580	1·921	Probable elevations
1862	6·494	1·835	
1863	6·498	1·839	
1864	6·570	1·911	
1865	6·476	1·817	
1866	6·468	1·809	
1867	6·615	1·956	
1868	6·557	1·898	
1869	6·435	1·776	
1870	4·620	1·961	
1871	4·472	1·813	
1872	4·468	1·809	
1873	4·516	1·857	
1874	4·358	1·699	
1875	4·40	1·741	
1876	4·46	1·801	
1877	4·56	1·901	
1878	4·68	2·021	
1879	4·64	1·981	

* See appendix 14, Report of Coast and Geodetic Survey, 1887.

The above series of tidal observations from 1870–79 were carefully examined for use in determining the mean sea level—M. S. L.—in New York harbor* and these values resulted:

Year.	Mean sea level above zero of staff.	Mean sea level above Battery datum.
1870	4·692 ft.	2·033 ft.
1871	4·545	1·886
1872	4·533	1·874
1873	4·612	1·953
1874	4·410	1·751
1875	4·505	1·846
1876	4·540	1·881
1877	4·630	1·971
1878	4·751	2·092
1879	4·688	2·029

The zero of the tide staff at Governor's Island was found by levelling to be 16·899 ft. below B. M.$_1$ in 1871–2 and 16·826 in 1875. Consequently the mean of these two values, 16·862 ft., has been adopted as the correct value for the series of observations 1870–79.

The elevations of half tide level†—H. T. L.—from 1853 to 1869 are subject to considerable uncertainty owing to changes in the elevation of the zero of the tide staff, of which no record appears to have been made. Such changes must have taken place in 1856, 1861, and 1870. In 1853 the zero of the tide staff was recorded as 17·00 ft. below B. M.$_1$, but this location does not harmonize with the succeeding observations and there is much evidence to contradict it.

We determine the probable elevations of H. T. L. at Governor's Island for the years 1861–69, by making the average H. T. L. for the four years 1866, '67, '68, and '69 have the same elevation as the average for the four years 1870, '71, '72, and '73: the elevations of H. T. L. for the years 1856–60 are fixed by giving the average of the observations for 1857, '58, '59, and '60, the same elevation as those of 1861, '62, '63, and '64; and finally we make the average H. T. L. for the three years 1853–55 the same as the average of the three years 1856–58. Very nearly the same values are arrived at if we start with the elevation 14·51 ft. of B. M.$_1$ above M. L. W. given in the Coast Survey Report for 1853. We also observe that the series of 1861–1869 shows no tendency toward increased elevation with the time, and for that reason they seem to confirm our location of the 1853–55 observations.

These elevations are still further shown to be the most probable ones, from the fact that in 1879 the elevation of B. M.$_1$

* Coast and Geodetic Survey Report for 1899, p. 404.

† Which is the average of high and low tides.

was given as 14·6 ft. above M. L. W. "from the observations of 1853 verified in 1873"; and that the observations of H. T. L. at Boston from 1853–5 and 1870–3 have substantially the same relative elevations and yearly fluctuations.

From October 2d to 30th, 1886, a series of comparative tidal observations were carried out at Governor's Island and Sandy Hook, and the resulting M. S. L. corrected for annual inequality above zero of staff at Governor's Island was 4·200 ft., with zero of staff at that time 16·43 ft. below B. M.,, making M. S. L. 1·973 ft. above Battery datum.

We next have the tidal observations at Sandy Hook, which are as follows:

Year.	M. S. L. and H. T L. above Sandy Hook datum.		Equivalent H. T. L. at Governor's Island above Battery datum.
1876	6·74	M. S. L. from hourly heights	1·774
1877	6·90		1·934
1878	7·06		2·094
1879	6·87		1·904
1880	6·84		1·874
1881	6·89		1·924
1882	6·90	H. T. L. from high and low waters (values in parenthesis partly estimated)	1·934
1883	7·02		2·054
1884	(7·17)		2·204
1885	(6·82)		1·854
1886	(6·90)		1·934
1887	6·91	M. S. L. from hourly heights	1·944
1888	7·00		2·034
1889	7·13		2·164
1890	7·05		2·084
1891	7·09		2·124
1892	7·05		2·084

The observations made at Sandy Hook were referred to a plane 17·63 below B. M. T.,* and are reduced to Battery datum by means of the simultaneous observations for the four years 1876–1879 at Governor's Island and Sandy Hook.

While spirit levels have been taken between Sandy Hook and Governor's Island, yet, owing to the considerable distance of the run, they are probably in error more than levels derived from the simultaneous tidal observations.

The levels derived from the four years of tidal observations agree almost precisely with the levels obtained from the simultaneous tidal observations in October, 1886, and are more suitable to reduce the Sandy Hook observations to simultaneous ones at Governor's Island than the spirit levels. From the spirit levels of 1887 as revised in 1899, the elevation of B. M.

* Described in C. and G. S. Report for 1887, appendix 14.
" " " 1899, page 472.

Governor's Island, above B. M. T. Sandy Hook was 1·361 ft., while from the simultaneous tidal observations of October, 1886, the difference was 1·468 ft., and from the tidal observations of 1876–9, 1·472 ft. This latter difference has been adopted in the reduction.

The observations at Sandy Hook have to be reduced to the equivalent values of half tide level at Governor's Island, which for the ten years 1870–79 was ·067 ft. lower than mean sea level, and consequently the elevations have been corrected by this amount in the column "Equivalent H. T. L. at Governor's Island above Battery datum."

The tidal records at Governor's Island from 1870–79 are particularly important in this investigation, and while the observations appear to be satisfactory, the frequent change of staffs make it desirable to have an independent check on their accuracy which we have in the observations at Sandy Hook in 1876–79, taken in connection with the levels obtained from the simultaneous tidal observations in October, 1886.

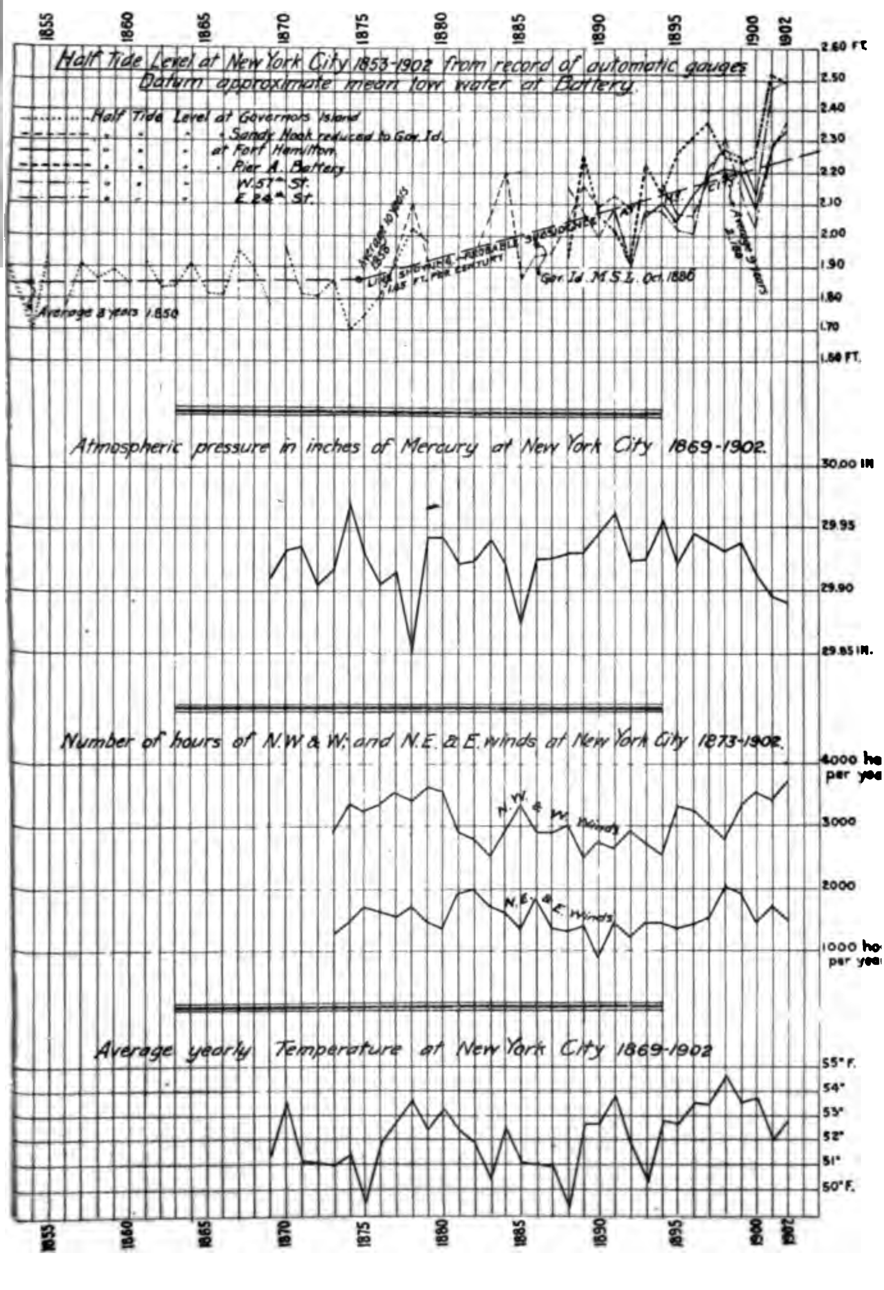
We next have a series of tidal observations at Fort Hamilton, N. Y., from 1893–1902, as follows:

Year.	H. T. L. above zero of staff.	H. T. L. above Battery datum.
1893	5·815 ft.	2·067 ft.
1894	5·885	2·137
1895	5·785	2·037
1896	5·875	2·127
1897	5·945	2·197
1898	5·960	2·212
1899	5·955	2·207
1900	5·820	2·072
1901	6·030	2·282
1902	6·085	2·337

The zero of the gauge at Fort Hamilton was 42·194 ft. below B. M. L. (destroyed in 1901), and 17·951 ft. below B. M., at Governor's Island, according to the Coast and Geodetic Survey levels of 1887. Two independent determinations of this difference in elevation have since been made, one in 1898 of 17·971 ft., and in 1900 of 18·019 ft. The 1887 value has been adopted, however, in the reduction of the staff readings to Battery datum.

Besides the above observations of the Coast and Geodetic Survey, we have the following tidal records of the Department of Docks and Ferries, all referred to Battery datum.

Diagram showing the yearly averages of Half Tide Level at New York City and the corresponding yearly averages of the principal meteorological phenomena.



	Half tide level above Battery datum.		
	Pier A.	West 57th St.	East 24th St.
1889	2·273 ft.	2·079 ft.	----
1890	2·063	1·990	----
1891	2·012	2·082	----
1892	1·910	1·902	----
1893	2·232	2·075	----
1894	2·133	2·075	2·164 ft.
1895	2·265	2·018	2·067
1896	2·314	2·003	2·053
1897	2·359	2·212	2·173
1898	2·258	2·278	2·301
1899	2·230	2·245	2·127
1900	2·250	2·127	2·012
1901	2·514	2·461	2·274
1902	2·490	2·492	2·361
1903	2·343	2·433	2·295

The yearly averages of half tide level at New York which have been given, are plotted in the diagram on page 339. They show a continual oscillation, having an amplitude of nearly 0·3 ft., about an average value which since 1875 has uniformly increased. These oscillations when considered in relation to the accompanying meteorological phenomena, also represented in the diagram, are seen to be mainly due to atmospheric pressure and winds. They are more or less perfectly eliminated by taking the average for five or more years, and when thus eliminated the observations appear to show that mean sea level remained nearly stationary from 1853 to 1875, since which time it has been rising relatively to the land by about 1·45 ft. per century. The rate of change since 1875 may be obtained in the following different ways.

(1) From ten years' observations at Governor's Island, 1870–79, the elevation of M. S. L. was 1·932 ft., and at Fort Hamilton the average elevation of H. T. L. from 1893–1902 was 2·165 ft.; allowing 0·03 ft. as the difference between M. S. L. and H. T. L. at Fort Hamilton, we have an increase in elevation of H. T. L. of 0·26 ft. in twenty-three years, or 1·1 ft. per century.

(2) The observations at Fort Hamilton alone, give the following result by taking the average H. T. L. of the first five and last five years of the series:

H. T. L. 1893–97	elevation........	2·108 ft.
H. T. L. 1898–1902	"	2·223

An average elevation of H. T. L. of ·115 ft. in five years, or 2·30 ft. per century.

(3) The tidal observations at Pier A for the last ten years,

1893–1902, give 2·304 ft. as the elevation of H. T. L. at Pier A, while H. T. L. at Governor's Island 1870–79 was 1·858 ft., an increase in the elevation of H. T. L. of ·446 ft. in twenty-three years, or 1·94 ft. per century.

(4) The observations at Governor's Island 1870–79 give

Elevation of M. S. L. 1870–74 ..... 1·899 ft.
Elevation of M. S. L. 1875–79 ..... 1·964

An increased elevation in M. S. L. of 0·065 ft. in five years, or 1·30 feet per century.

(5) The observations at Sandy Hook for the seventeen years 1876–1892 give:

Elevation of M. S. L. 1876–1881 ..... 6·883 ft.
Elevation of M. S. L. 1887–1892 ..... 7·038

An increased elevation in M. S. L. of 0·155 ft. in eleven years, or 1·41 ft. per century.

(6) The observations for the fourteen years 1889–1902 at Pier A, when taken by themselves, give:

Elevation of H. T. L. 1889–1895 ..... 2·127 ft.
Elevation of H. T. L. 1896–1902 .... 2·345

An increased elevation in H. T. L. of 0·218 ft. in seven years, or 3·1 ft. per century.

(7) The average of the observations of H. T. L. for the ten years 1870–1879 at Governor's Island, compared with all the above mentioned observations at New York for the nine years 1894–1902, shows that H. T. L. has risen ·326 ft. in twenty-two and one-half years, or at the rate of 1·45 feet per century.

(8) The Department of Docks and Ferries of New York City found it necessary in 1898 to raise their plane of mean low water (to which soundings are reduced) 0·24 ft. above that in use since 1872; and the U. S. Engineers in 1900 raised their plane of mean low water 0·32 ft. above that used in 1872.

On account of the many disturbances to which tidal observations are subject, the frequent change of tide staffs in some cases, and the settlement of bench marks, it is necessary to use considerable caution in the interpretation of the observations, and all possible checks should be used. Only when independent determinations show a reasonable agreement, can we feel sure of the result arrived at.

Besides the errors which may occur in the measurement of the elevation of mean sea level, it is subject to changes from many causes, among which may be mentioned changes in atmospheric pressure, winds, temperature, various tidal components having periodicities ranging from six hours to nineteen years, river outflow, evaporation, changes in ocean currents, melting of polar snow and ice, changes in salinity,

detritus carried into the sea by rivers, and the wearing away of shores, as well as changes in the position of the earth's axis and speed of rotation.

High and low waters only were measured in most of the observations, and consequently H. T. L., which is the mean of the above quantities, has been given in the tables, except in a few instances.

In general M. S. L. obtained from hourly ordinates, which determines a level surface, differs from H. T. L. to a small extent, depending in amount on the shape of the tide wave. In deep water this difference is usually quite small, but in shallow water, or where the tide wave is obstructed, it requires to be taken into account.

It has been computed from the tidal constants that M. S. L. is 0·01 ft. above H. T. L. at Sandy Hook, and 0·067 ft. above at Governor's Island. The differences are about the same at Pier A, West 57th st., and East 24th st., as they are at Governor's Island, so far as present information goes, and at Fort Hamilton the difference is estimated to be about 0·03 ft. The Sandy Hook observations, only, have been corrected to H. T. L. at Governor's Island in the above tables.

The settlement of bench marks would make the sea appear to rise in relation to the land by the entire amount of the settlement. Consequently all bench marks should be carefully checked to guard against any change, and this has been done in the case of B. M., and B. M. L. mentioned above.

The accuracy of the tidal averages of H. T. L. obtained from an automatic tide gauge varies somewhat with the type of the instrument employed, and the attention given to it. The results are most accurate where the tidal range is small, and the working scale of the gauge large. An examination of the yearly means of the various tidal observations goes to show that the yearly averages of half tide level should not have a probable error greater than 0·05 ft., although the maximum error may be nearly three times as great. The greater part of this probable error is due, however, not to the inaccuracy of the tide gauge, but to fluctuations of the mean sea level from meteorological causes.

When we examine the daily changes of mean sea level in New York Harbor, we find that they are mainly determined by the velocity and direction of the wind. N.W. and W. winds are the effective agents in depressing the sea level and N.E. and E. winds in raising it.* The mean level has been at times raised

* Des Barres in his charts of New York Harbor published in 1780, says, "Tides rise perpendicularly about seven ft., but are sometimes checked to such a degree by the Westerly or North Westerly winds, as to lower the water on the bar to three fathoms and one-quarter, and Easterly or North Easterly winds have frequently risen it to five fathoms."

or depressed as much as three feet from its average elevation during strong gales in the above directions.

When we pass from the daily changes to the monthly averages of mean sea level, we find a remarkable correspondence between the height of mean sea level and the movement of the northwest and west winds, while the northeast and easterly winds appear to have little effect on these monthly averages. Probably the greater and more uniform effect of the westerly winds, which has been proved by analysis for a long series of years, is due to the fact that they are the prevailing winds, last for a considerable time, have greater intensity, and are effective over large areas, while the easterly winds are more local, and changeable.

The atmospheric pressure does not usually appear to have an important share in determining the monthly values of mean sea level, except as it influences the intensity of the prevailing westerly winds.

These monthly averages show a minimum mean sea level, sharply defined in January, and a maximum mean sea level, not sharply defined in August; while the westerly winds have a maximum sharply defined in January, and a minimum not sharply defined in August. This seasonal difference in elevation of mean sea level averages 0·55 ft. By means of yearly averages we eliminate these seasonal fluctuations as well as all astronomical effects, except that having a period of 19 years, which is so small in this latitude (less than 0·2 inch) that it may be neglected.

Particularly noticeable in the tidal curves is the very considerable depression of half tide level in 1874, and the great elevation of half tide level in 1878. When compared with the curve of atmospheric pressures, it will be noticed that abnormal changes of the barometric pressure occurred in those years, which seem to show that they occasioned the tidal fluctuations.

Tidal elevations and barometric pressures at a number of stations on both sides of the Atlantic show that these atmospheric surges extended over a large area, and similarly affected all tide gauges on the North Atlantic Ocean.

In the year 1900 a marked depression in half tide level is shown by the New York observations. As this same depression was observed at Fernandina, Fla., and other points, we may presume that it took place along the entire Atlantic Coast. At New York City, it appears to have been caused by the unusual strength of the N.W. and W. winds.

In 1901 and 1902 mean sea level at New York City rose to a height not before attained, which was probably due to the low barometric pressure prevailing during those years.

As the effect of the atmospheric pressure and winds on the sea level at any place is the integral of their effects taken over a wide area, while these observations are taken at only one point, a close correspondence is not to be expected, particularly where the locality is at the junction of continental and ocean areas, as in this case.

It has been recently found from the yearly averages of atmospheric pressure at many widely separated places, that abnormal variations of atmospheric pressure occur of considerable duration, which are apparently caused by the surging to and fro of the atmosphere. They affect a very considerable area and have a tendency to recur in periods of about three and eight years, corresponding closely with periodic variations of solar energy received by the earth.

The examination of long series of tidal observations in places scattered over the world discloses very similar periodicities, which are doubtless due in the main to the surging of the barometric pressure before alluded to, and the consequent change in the atmospheric circulation.

Tidal observations from Maine to Florida disclose a striking similarity among the changes in half tide level at all localities on the Atlantic Coast, and the same phenomena have been observed on the shores of the Baltic Sea. It appears quite certain that these fluctuations of yearly half tide level, nearly alike in direction and amount, are due mainly to changes in the mean annual barometric pressure, and the accompanying changes in wind velocities. These periodic fluctuations, never more than a few years in duration and very much alike in extent and direction at all the points embraced in a large area, evidently are changes due entirely to the sea, and can in no way be considered as showing a change in the absolute elevation of the land.

On the other hand, there are no changes in the meterological phenomena which will account for a continuous increase of half tide level for a series of years, such as have been observed at New York from 1875 to 1902, at Boston for the same period, and at Penobscot Bay from 1870 to 1885. Neither will such changes account for the continuous depression of sea level shown by the series of observations at Stockholm, Sweden, commencing in 1774, and verified by numerous observations along the Swedish coast of the Baltic Sea, where it has been found that the land has risen nearly two feet relatively to the sea, while equally reliable observations on the German coast of the Baltic Sea, dating from 1811, show no appreciable change in level.

No long period or continuous variations of atmospheric pressure, winds, temperature, ocean currents, etc., appear to exist to

explain these secular changes in mean sea level, and if such changes did occur, they could hardly explain the difference in amount and direction of the changes of sea level observed at different points. Besides, it is seen from tidal observations on the German coast of the Baltic Sea, the North Sea, and the coast of India, that no continuous change in ocean level has occurred in those places, which would probably be the case if there had been any great or long continued change in absolute ocean levels elsewhere.

We must conclude, then, except for minor variations due to meteorological conditions, that it is the land and not the sea which is changing in elevation.

Most of the geological evidence appears to show that the movement of the land relatively to the sea in recent geologic times has been of a cyclic character and confined within narrow limits. There is little geologic evidence to be found in the vicinity of New York of a definite character to indicate depression. It is true that marsh sod can be found outshore from the beach, and below mean sea level; that cedar trees die out on the shore, and that peat bogs and stumps of trees have been found in many places below sea level. These phenomena are to be explained, however, by the inroads of the sea during storms, and by wave action; as well as by the compression and consolidation of the marsh land, which has been known to sink as much as three feet when drained, or loaded with sand. As we leave the shore these apparent evidences of subsidence disappear and in places thoroughly protected from the sea few or none of them are found.

It does not appear from the evidence presented by tidal records, or from historic or geologic evidence, that our sea-coast is in any immediate or serious danger from subsidence of the land, for almost without exception the longest records show the least change, and were it not for the power and efficiency of modern dredging machinery the shoaling of harbors would probably be a more serious affair.

The tidal observations have been taken for so short a time, however, that they can only tell us what has been going on recently, and do not disprove a possible change in ocean elevation too small to be detected within the period of observation.

In conclusion it may be stated with confidence, as the result of an inspection and study of tidal observations on both sides of the Atlantic for the first time brought together,

(1st) That the mean sea level oscillates in an irregular manner, having an average period of about eight years. These oscillations closely resemble one another at many ports distant from each other, and appear to be largely due to changes in

atmospheric pressure, and the resulting changes in wind velocities.

(2d) The above oscillations compensate themselves completely in the course of time, and do not give rise to a continuous movement in a given direction.

(3d) That in addition to the above movements of the sea some ports show a more or less continuous rising of the sea relatively to the adjacent land; others a lowering of the sea level in its relation to the land, and still others maintain a constant relation between the two. These latter make it clear that except for the periodic changes noted above, the sea does not change its level, and that the relative changes are due to land movements.

(4th) At various ports the rate of change in the elevation of mean sea level referred to the adjacent land has not remained constant, but has varied in a considerable degree. All the observations show that for long periods the rate of change is less than took place in some part of that period, and the evidence is strong that the movement is not continuous, but oscillatory and confined within narrow limits.

(5th) The observations at New York City show that since 1875 the land has been subsiding relatively to mean sea level by about 1·45 ft. per century, but from the establishment of the self-registering tide gauge in 1853 to that date, little or no change had occurred, and it is improbable that the present rate of subsidence will be continued indefinitely.

ART. XXXI.—*On the Geology of Brome Mountain, one of the Monteregian Hills;* by JOHN A. DRESSER.

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IN the western part of the province of Quebec, the basin between the Appalachian Hills on the southeast and the southern edge of the old, but now elevated, Laurentian peneplain* at the northwest, is about eighty miles wide. It is occupied by rocks of Paleozoic age in which the geological scale is represented from Cambrian to Lower Devonian, both inclusive. This basin has a nearly level surface except for the presence of a series of hills, eight in number, known as the Monteregian Hills.† Six of these, namely, Mount Royal, Montarville, Beloeil, Rougemont, Yamaska and Shefford, rise at somewhat regular intervals of about ten miles, and in a nearly east and west line. They thus extend for a distance of fifty miles eastward from Mount Royal and from the city of Montreal at its base. Brome Mountain and Mount Johnson are respectively two and a half and six miles south of Shefford and Beloeil. Mount Royal, which is probably the lowest, is 769·6 feet above mean sea level, while Shefford has an altitude of 1,600 feet. Rougemont, Montarville and Yamaska have not yet been determined. The others are intermediate between the heights given, Brome reaching an altitude of 1500 feet.

Considered physiographically, these hills are of residual origin, having been etched into their present relief by the extensive denudation of the region by which not less than one thousand feet of the plain have been removed. The composition and texture of the rocks which compose these hills have evidently offered so much greater resistance to denuding agencies than was afforded by the surrounding strata as to give the hills their present elevation. Hence they are hills of the butte type.

Reports on the geology of the district, with more or less attention to the petrography of these hills, have been made by Dr. T. Sterry Hunt in 1858, by Sir William Logan in 1863 and by Dr. R. W. Ells in 1894.‡

Dr. F. D. Adams in 1903§ made a general review of these hills and proposed for them the name "Monteregian", (Mons Regius), and also gave a detailed description of Mount Johnson. Fig. 1 of this sketch is reproduced from Dr. Adams' paper. The writer is also indebted to Dr. Adams for valuable advice on many points in connection with this investigation.

* Dr. A. W. G. Wilson, Journal of Geology, vol. xi, No. 7, "The Laurentian Peneplain."

† Dr. F. D. Adams, Journal of Geology, vol. xi, No. 3. "The Monteregian Hills—a Canadian Petrographical Province."

‡ Geological Survey of Canada. § Op. cit.

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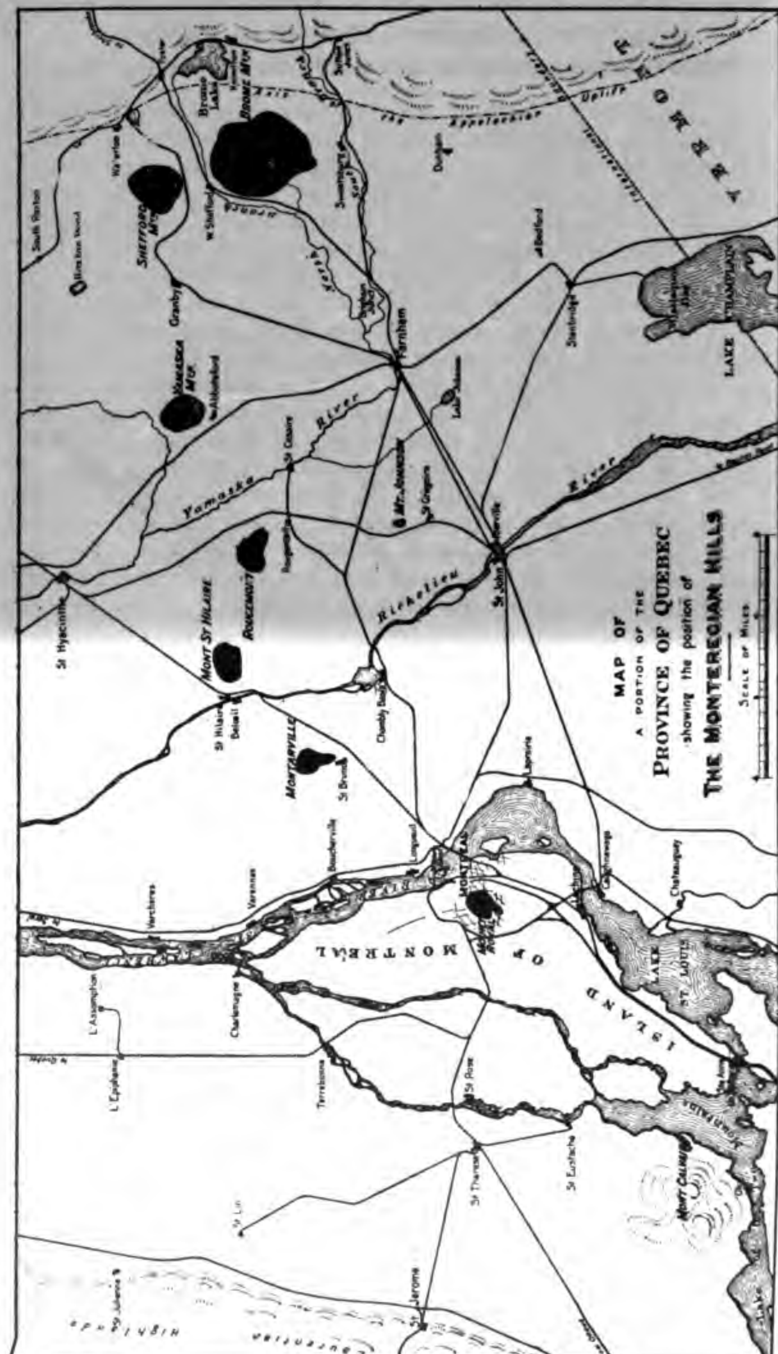
MAP OF
A PORTION OF THE
PROVINCE OF QUEBEC
showing the position of
THE MONTEREGIAN HILLS
SCALE OF MILES
BROME MTN
Brome Lake
SHEFFORD MTN
YAMASKA MTN
Granby
Farnham
Yamaska River
Richelieu River
St Johns
ROUGEMONT
MONT ST HILAIRE
St Hyacinthe
MONTARVILLE
MONTREAL
ISLAND OF MONTREAL
LAKE ST. LOUIS
LAKE CHAMPLAIN
St Jerome
Laurentian Highlands

In 1901 the present writer completed a report* on Shefford Mountain which is now in press, and published a résumé of it in the American Geologist for October of that year (vol. xxviii).

The above mentioned investigations have shown that the Monteregian Hills are of igneous origin and are intrusive in their relations to the strata surrounding them. As a petrographical province they are distinguished by two main rock types, one representing a basic magma of the essexite class in the Rosenbusch classification—the other, various types of alkali-syenite. In structure Mount Johnson, and probably Mount Royal, are true volcanic necks, while Shefford has been found to be a laccolite.

It is the purpose of the present paper to outline the main features of Brome Mountain, and to indicate its general relation to the other hills of the Monteregian series that have been thus far studied.

Brome Mountain is the largest hill of this series. It comprises an area of about thirty square miles in the counties of Brome and Shefford. Together with Shefford Mountain, which stands two and a half miles to the north, and is next to it in size, Brome is the most easterly of the Monteregian Hills. In form it is rudely circular. The central portion, about Brome pond, is a nearly level basin two and a half by one and a half miles in extent, and overlain by heavy beds of post-glacial clay. The interior basin has an average altitude of about five hundred feet above sea level, or only a little above the country surrounding the mountains; while the basin is encircled by a rim of hills which rise to heights of from six hundred to one thousand feet above the surrounding plain, or one thousand to fifteen hundred feet above the sea. "Pine Mountain" is the highest point.

In common with the other hills of the Monteregian series, Brome is an igneous mass intrusive through Paleozoic strata. The latter belong to the Sillery division of the Cambrian system on the north, east, and south sides of Brome mountain, and on the west to the Mystic series (D2*b*) of the upper Chazy†.

The latest time at which the intrusion could have taken place is also indicated, though less definitely, by the fact that the igneous rocks are somewhat foliated, and show in places an incipient schistose structure. This is parallel in direction with the schistosity of the surrounding sediments, though much less in degree, and represents a late stage in the folding of the Appalachian uplift. As this was not shared in by the Permo-Carboniferous of the maritime provinces, Brome mountain was formed after the deposition of the upper Chazy sediments and before the close of the Carboniferous period.

* Geological Survey of Canada, vol. xiii, part L.

† Dr. R. W. Ells, Annual Report of the Geological Survey of Canada, 1894.

This age limit virtually agrees with that of the adjacent intrusion of Shefford mountain which shows similar dynamic metamorphism, but cuts slightly later strata, viz., The Farnham black slates (D3*a*), a division of the lower Trenton. The latter, however, do not occur at Brome.

The presence of numerous sedimentary outliers which have been invaded and otherwise altered by the igneous rocks beneath, together with the general character of those rocks, and the absence of any tufaceous material, seems to indicate that Brome mountain is an uncovered laccolite and has never been an active volcano. The evidences of a similar structure at Shefford mountain are most conclusive, and as the distance between the mountains is only two and a half miles, which is less than the smallest diameter of either, they are probably parts of a single laccolite. The correspondence of the rocks in the two masses also favors this view.

Petrography.

The igneous rocks of which Brome mountain is essentially composed belong to three principal types, two of which certainly are the products of separate irruptions, and the third possibly so. The rock of the earliest intrusion is of the Essexite family, according to the Rosenbusch classification, or in the Quantitative Classification* it is a Hessose.

The second is of a syenitic character ranging from Nordmarkite to Nepheline syenite. It is Nordmarkose in the Quantitative Classification. The third, which is of comparatively small extent, is a porphyritic rock which from its microscopic and chemical character is classed as a phyro-laurdalose. Their distribution is shown on the accompanying figure (2).

The nordmarkose distinctly cuts the hessose, but the contact of the laurdalose with the nordmarkose, which completely surrounds it, is everywhere drift-covered so that conclusive evidence of their relations could not be obtained.

Hessose.—This is a massive rock, gray in color, and weathering to a dull brown. Its structure is granitoid and the texture medium. Feldspar and small amounts of dark minerals, chiefly hornblende, mica, and iron ore, can be seen by the unaided eye.

In the thin section feldspar is found to constitute fully 90 per cent of the rock, in parts that are considered typical, the remaining constituents being pyroxene, olivine, and biotite with accessory magnetite and apatite. Hornblende in many cases occurs quite as abundantly as pyroxene, but in other parts of the rock is entirely wanting. The structure in general is hypidiomorphic granular.

* "Quantitative Classification of Igneous Rocks," Cross, Iddings, Pirsson and Washington, The University of Chicago Press, 1903.

The feldspar is chiefly a plagioclase, which is twinned according to the albite law in broad lamellæ upon which it extinguishes symmetrically an angle of 40 degrees or more. It is bytownite, or basic labradorite. A few rather large crystals of microperthite are the only other feldspathic constituents seen.

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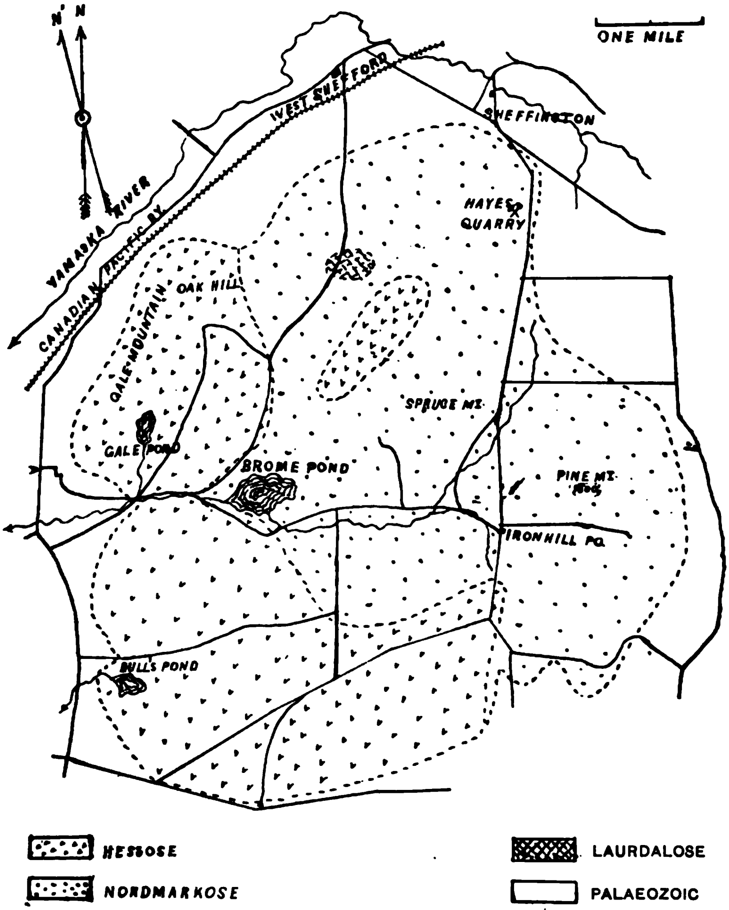


Map of Brome Mountain, Quebec, Canada.

The hornblende is trichroic, the scheme of absorption being $\mathfrak{c} > \mathfrak{b} > \mathfrak{a}$, with $\mathfrak{b}$ nearly equal to $\mathfrak{c}$. The color ranges from chestnut to yellowish brown. The maximum extinction angle, $\mathfrak{c} \wedge c$, that was observed was 20 degrees.

The principal variety of augite present is slightly dichroic. Sections having $\mathfrak{b}$ or $\mathfrak{c}$ parallel to the plane of the polarizer of

the microscope are gray, or grayish green: those with *a* in the same position are flesh-colored. In a few instances grains of another variety of augite are possibly present, but the amounts are too small to admit of satisfactory determination.

Olivine, where present, is colorless, and is serpentinized along cracks in the primary mineral.

Biotite occurs in irregular areas having imperfect crystallographic outlines.

Magnetite, sphene, apatite, and occasionally a little nepheline in a decomposed condition are also present but present no features worthy of further notice.

An analysis by Mr. M. F. Connor of the Geological Survey of Canada gave the result I in the following table; II is an analysis of Akerose (Essexite) from Shefford mountain, also by Connor; III, of Andose (Essexite) from Mount Johnson, and IV, the original Essexite from Salem, Mass.

	I.	II.	III.	IV.
SiO_2	44·00	53·15	48·85	47·94
Al_2O_3	27·73	17·64	19·38	17·44
Fe_2O_3	2·36	3·10	4·29	6·84
FeO	3·90	4·65	4·94	6·51
MgO	2·30	2·94	2·00	2·02
CaO	13·94	5·66	7·98	7·47
Na_2O	2·36	5·00	5·44	5·63
K_2O	·45	3·10	1·91	2·79
P_2O_5	·20	·65	1·23	1·04
TiO_2	1·90	1·52	2·47	·20
MnO	·08	·46	·19	....
H_2O	·80	1·10	·68	2·04
	100·01	99·64	99·36	99·92

The calculation of the norm of I in order to refer it to its proper place in the Quantitative Classification gave the following results:

The norm of I:

Orthoclase		2·22
Anorthite		63·90
Albite		14·67
Nepheline		2·84
Diopside	17CaOSiO$_2$, 13MgOSiO$_2$, 4FeOSiO$_2$	3·80
Olivine	44MgO, ½SiO$_2$, 12FeO, ½SiO$_2$	4·30
Ilmenite		3·65
Magnetite		3·48
Apatite		·34
Water		·80
		100·00

ock accordingly falls in

Class II,	Dosalane	
Order 5,	Germanare	
Rang 4,	Hessase	
Subrang 3,	Hessose	
		(Grad-polmitic)
		(Sub-Grad. premirlic)

al mineral composition being practically normative, structure megascopically granitic, the rock is, there-ssed as a *grano-hessose.*

rdmarkose.—This is also a plutonic rock of medium texture and gray or reddish gray color. In the hand it shows only feldspar with an occasional speck of

thin section feldspar is found to make up probably 90 of the volume of the rock. The remaining constit- order of relative abundance are biotite, pyroxene, ide, sphene, apatite. Biotite and pyroxene, and occa- hornblende, may be ranked as essential constituents. more than equals in amount all the other constituents eldspar. Occasionally a little nepheline is seen and in rts a few grains of quartz. Logan mentions* the spe-vity of this rock as 2·632–2·638.

eldspar resembles orthoclase in its general appearance, a mottled look, and under higher powers proves to ine perthitic intergrowth in the spotted areas.

also are found to be more numerous under higher ing powers, apparently their extent being limited only power of the microscope. The feldspar is, therefore, l as cryptoperthite. Logan (op. cit.) reported its spe-vity to be 2·575 and gave the following analysis (V) of grains. VI is an analysis of cryptoperthite from , Norway, by Gmelin, described by Brögger (Syenit-tgänge, p. 524).

	V.		VI.
SiO_2	65·70		65·90
Al_2O_3	20·80		19·46
CaO	·84		·28
Na_2O	6·52		6·14
K_2O	6·43		6·55
H_2O	·50		·12
		Fe_2O_3	·44
	100·79		98·90

*Geology of Canada, 1863, p. 656.

Hornblende is green in ordinary light and shows pleochroism. It is in so small amounts, however, that the scheme of its absorption could not be satisfactorily determined.

The other minerals require no special note. Where quartz enters into its composition this rock is identical with the Nordmarkose (Nordmarkite) of Shefford Mountain. In other phases it closely resembles the Laurvikite of Southern Norway described by Prof. W. C. Brögger. Its resemblance to both is shown in the following analyses.

	VII.	VIII.	IX.	X.
SiO_2	61·77	58·88	65·43	59·96
Al_2O_3	18·05	20·30	16·96	19·12
Fe_2O_3	1·77	3·63	1·55	1·85
FeO	1·75	2·58	1·53	1·73
MnO	·08	....	·40	·49
CaO	1·54	3·03	1·36	2·24
MgO	·89	·79	·22	·65
Na_2O	6·83	5·73	5·95	6·98
K_2O	5·21	4·50	5·36	4·91
P_2O_5	·15	·54	·02	·14
TiO_2	·74	....	·16	·66
H_2O	1·10	1·01	·82	1·10
	99·97	100·99	99·74 x	99·83 ^

x SO_3 .... —·06 ^ BaO .... —·12

SO_3 .... —·08

Cl .... —·04 Cl .... —·14

VII. Nordmarkose, Brome. Analysis by M. F. Connor.
VIII. Laurvikose, Byskoven, near Laurvik, Norway. ("Chemical Analyses of Igneous Rocks," by H. S. Washington.)
IX. Nordmarkose, Shefford. Analysis by M. F. Connor.
X. Laurvikose " " " "

The norm of VII is as follows:

Orthoclase	31·14
Albite	57·11
Anorthite	2·78
Nepheline	·28
Olivine	·62
Diopside	3·16
Apatite	·34
Ilmenite	1·37
Magnetite	2·55
	100·45

The place of the rock in the quantitative classification is as follows:

Class I,	Persalane
Order 5,	Canadare
Rang 1,	Nordmorkase
Subrang 4,	Nordmarkose

In structure it is megascopically granitic and, therefore, becomes a grano-nordmarkose. It, too, is approximately normative. The chief departure of the norm from the mode is in the alkali feldspars, which in the rock are in the form of microperthite.

Laurdalose.—This is a porphyritic rock having a greenish matrix and a few phenocrysts of light gray color.

In the microscopic section the rock is seen to be porphyritic with a felsitic base. The phenocrysts are found to be feldspar, generally of the character of that mineral in the nordmarkose. No plagioclase was certainly seen. Part of the feldspar appears to be pure orthoclase but more possesses the mottled character of cryptoperthite. Patches of granular feldspathic-looking material are also numerous and are prominent in the cryptocrystalline groundmass of the rock. Granular ferromagnesian minerals are also found in some of these aggregates.

Magnetite and apatite in small amount are also present. Sodalite appears in bluish individuals having rounded or polygonal outlines. It is perfectly isotropic, showing no pleochroism, even with a gypsum plate producing red of the first order, and yields no interference figure in condensed light. The dust-like inclusions characteristic of this mineral too are noticeable. A little chlorite and a few individuals of biotite are also seen.

	XI.	X.	XII.
SiO_2	55·68	59·96	55·65
Al_2O_3	20·39	19·12	20 06
Fe_2O_3	2·10	1·85	3·45
FeO	1·95	1·73	1·25
MgO	·80	·65	·78
CaO	1·92	2·24	1·45
Na_2O	9·18	6 98	8·99
K_2O	5·34	4·91	6·07
TiO_2	·60	·66	....
P_2O_5	·06	·14	....
MnO	·31	·49	....
H_2O	1·50	1·10	1·51
	99·83	100·17	99·21

XI. Laurdalose, Brome. Analysis by M. F. Connor.

X. Pulaskite, Shefford (Laurvikose), by M. F. Connor.

XII. Tinguaite, Hedrum, Norway (Laurdalite). Analysis by V. Schemlck. Described by W. C. Brögger. ("Chemical Analyses of Igneous Rocks," H. S. Washington.)

The norm calculated from this analysis is as follows:

Orthoclase	31·69
Albite	27·77
Nepheline	25·56
Acmite	2·31
Diopside	7·85
Olivine	·24
Ilmenite	1·06
Magnetite	1·86
Water	1·50
	99·84

It is therefore classed as follows—.

Class II,	Dosalane
Order 6,	Norgare
Rang 1,	Laurdalase
Subrang 4,	Laurdalose

The structure of this rock is both macroscopically and microscopically porphyritic.

As sodalite is one of the few distinguishable minerals in it, and is indicative of its alkaline character, it might best be designated as a sodalite-bearing felsophyro-laurdalose.

Comparison of Brome and Shefford.

When compared with Shefford Mountain the similarity of the two hills is found to be very close. In Shefford Mountain there have been three separate eruptions and the rocks thus produced in order of intrusion are very similar to those of Brome.

Shefford	Brome
1st, Akerose (Essexite);	1st, Hessose
2d, Nordmarkose (Nordmarkite)	2d, Nordmarkose
3d, Laurvikose (Pulaskite)	3d, Laurdalose

The rocks of the first intrusions in the two hills thus correspond very closely while those of the second are identical, while the third classes do not differ widely.

In point of general structure the hills are practically alike except that dikes later than the main mass of the mountain are very numerous at Shefford while they are almost altogether wanting at Brome.

Chemical Composition of Original Magma.

An effort was made to ascertain the chemical composition of the original magma which produced these rocks. The present surface exposure of the mountain may be taken as affording an average cross section of the mass. Accordingly, the relative

areas occupied by the three rock types at Brome were ascertained by placing a tracing of the map upon a sheet of square ruled paper and counting the squares occupied by each.

Taking the area of laurdalose as the unit, nordmarkose and the hessose occupy 150 and 110 units respectively. Multiplying their analyses by these coefficients of area, and dividing the sum of the products by the sum of the coefficients, the mean of the means obtained is that given as analysis XVII.

The analyses of the three related rocks in Shefford Mountain were treated in a similar manner, and the result given as analysis XIII.

But since the two mountains are to be regarded as parts of the same laccolite it is necessary to find the average of these means. This having due regard for the area of the two masses is found to be that given under XVIII.

	XVII.	XIII.	XVIII.
SiO_2	54·25	59·51	55·47
TiO_2	1·23	·78	1·13
Al_2O_3	22·14	17·90	21·17
Fe_2O_3	2·03	2·17	2·07
FeO	2·66	2·64	2·66
MnO	·12	·45	·20
MgO	1·48	1·27	1·44
CaO	6·77	3·09	5·93
K_2O	3·23	4·46	3·52
Na_2O	4·95	5·98	5·19
P_2O_5	·17	·27	·12
H_2O	·98	1·00	·99
	100·01	99·52 x	99·89
xBaO		·08	
CO_2		·13	
SO_3		·14	
Cl		·08	

A rock having the composition of the mean of Brome Mountain should be classed as follows in the Quantitative Classification:

Class I,	Persalane
Order 5,	Canadare
Rang 3,—	(alkalicalcic)
Subrang 4,—	(dosodic)

The mean composition of Shefford Mountain, XIII, would be classed thus:

Class II,	Dosalane
Order 5,	Germanare
Rang 3,	Andase
Subrang 4,	Andose

Such a rock would stand nearly on the line between the persalanes and the dosalanes, the ratio of the salic to the femic minerals being 85·33 : 12·40.

The average composition of the Brome and Shefford laccolite, as indicated under XVIII, would therefore give a rock which would be classed thus:

Class I,	Persalane
Order 5,	Canadare
Rang 3,——	(alkalicalcic)
Subrang 4,——	(dosodic)

This agrees with the mean of Brome, and differs but slightly from that of Shefford which stands very near the dividing line between Classes I and II, while they quite agree in the subordinate part of their classification as to Order, Rang and Sub-Rang.

The general mean of the two hills, as well as that of Brome, thus falls in a part of the scheme of the Quantitative Classification that has not yet been occupied. Being hypothetical rocks, however, they do not warrant the introduction of a new name, nor is it necessary, since their position can be otherwise definitely indicated by means of this admirable system of classification.

ART. XXXII.—*The Crystallization of Molybdenite;* by A. J. MOSES.

THE only satisfactory measurements of molybdenite crystals which have been made are those of Brown* upon material from Frankford, Pa. The earlier measurements of Hörnes were discredited by Kenngott's later examination and those of Knop were evidently made upon bent crystals.

The difficulties in the way of measurement are the striations upon the pyramidal faces which produce multiple and blurred images of the collimator signal and the frequent bending of the crystals as shown by grooves and ridges† upon the cleavage surface which frequently form three systems, each perpendicular to an edge of the hexagonal surface. In some cases these grooves are at many angles without any apparent law.

In a careful examination of a number of molybdenite crystals I have obtained some results which are worthy of record. In some cases, as in the Warren, N. H. crystals, the interpretation of the results may not be the correct one.

1. Molybdenite from Enterprise, near Kingston, Ontario.

In a quantity of material obtained from Mr. C. W. Dickson there was one doubly terminated crystal (fig. 1), about 8^{mm} across by 2^{mm} thick, the pyramidal faces of which were bright, a little curved and almost free from striations, and the terminal plane, which did not appear to be a cleavage, was bright and showed few grooves.

The crystal was attached to a gangue of pyroxene, phlogopite and pyrrhotite but projected so that it was possible to measure the angles between the basal plane and two of the pyramidal faces.

The faces did not yield single images and two separate adjustments were made for each angle with different combinations of lenses. The results, each in itself an average of four or more measurings, were:

First angle.	Second angle.
41° 21½′	41° 28′
41 53	41 02

Average of all, 41° 26′.

This corresponds to a pyramid $(20\bar{2}5)$ the angle for which calculated to Brown's unit would be 41° 23′.

* Proc. Acad. Nat. Sci. Phila., 1896, p. 210.

† Brögger showed (Zeitschr. f. Kryst. x, 507, 1885) that such markings could be produced by pressure, and Mügge attributed them (N. J. f. Min. 1898 i, 109) to translation along the plane 0001 perpendicular to the markings.

2. *Molybdenite from Aldfield, Quebec.*

A specimen purchased from the Foote Mineral Co. showed a barrel-shaped crystal (fig. 2), the basal plane 7×5^{mm}, thickness 4^{mm}. The cleavage surface was not crumpled and was free from grooves and ridges but was pitted with little etch figures of not very definite shape. The pyramidal planes were striated.

When adjusted on the two-circle goniometer by use of this pitted cleavage surface, it was found that, at intervals of closely 60° of the vertical circle, zones were obtained which yielded images of the collimator signal for two different positions, both positions corresponding to a bright illumination of the entire face. That is, the striations in this crystal are due to an oscillation between two forms and not to gliding or translation, this being further proved by the absence of grooves and ridges on the cleavage.

In each zone one of the two images corresponded to ρ approximately 90°. The crystal was therefore readjusted until these were exactly 90° and the results for the second image thereafter in four zones were:

ϕ	ρ	
0°	77°20′	Dull image
59°41′	77 21	Single image
120 09	77 10	Brighter of two
180 10	77 22	" " "

Average $\rho=77°$ 18′.

The variation of both ϕ and ρ are not too great to be attributed to the blurred signals. For the pyramid $(20\bar{2}1)$ observed by Brown at Frankford, Pa., the corresponding calculated angle is 77° 13′.

That is, the crystal consists of a predominant pyramid $(20\bar{2}1)$ with striated faces, and these striæ are due to an oscillation between this form and the prism*.

3. *Molybdenite from Cape Breton.*

Among a number of small crystals of molybdenite in the Egleston Museum labelled Cape Breton, one small crystal 4^{mm} broad by 1^{mm} thick showed five faces of a pyramid, two of which were unusually bright and intersected in a sharp edge. Placed with this edge vertical in the No. 2 Fuess goniometer, each face yielded a single vertically distorted image and permitted a rather close reading. The interfacial angle obtained was 58° 28½′, which corresponds to an angle with the cleavage of 77° 29′. The calculated angle for $(20\bar{2}1)$ is 77° 13′.

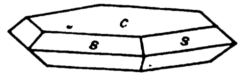
* The faces of such crystals are slightly curved and the crystals taper, preventing an exact application of a hand goniometer. It is probable that the angle $cp=72°$ obtained by Hidden, (this Journal, xxxii, 210, 1886) on Renfrew molybdenite in this way is due to an oscillatory combination.

4. *Molybdenite from Okanogan Co., Washington.*

Messrs. Geo. L. English & Co. permitted me to examine over one hundred crystals from this locality. Many of these suggested a pyramid approximately the $(20\bar{2}5)$ found upon the crystal from the Enterprise Mine, but the crystals were bent and the faces bruised and rounded. Etch figures $\frac{1}{2}$ to 1^{mm} across and six-sided in cross section were observed and upon one crystal in which they were unusually distinct their parallelism to the hexagonal outline of the crystal was shown by the cross hairs of the microscope. This particular crystal also showed three systems of fine lines *parallel* to the edges of the cleavage in addition to a few coarse grooves perpendicular to these edges.

The best measurements were obtained from a crystal (fig. 3)

1



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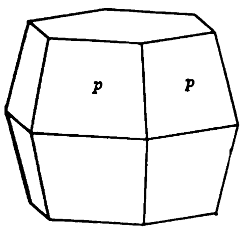
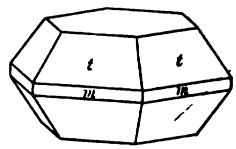
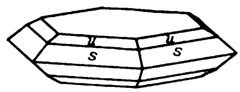


4



3



which distinctly showed two pyramids, the brighter being the flatter form but the steeper form being more developed. The crystal formed one of a group and only two zones could be adjusted for measurement. The images were multiple but the groups were small and the angles with the cleavage were:

Zone 1.	30° 17′ and	41° 46′
" 2.	29 32	Blurred
Average	29° 54′	41° 46

The nearest *simple* indices are $(10\bar{1}4)$ (28° 51′) and $(20\bar{2}5)$ 41° 23′. If 41° 46′ be taken as the angle of the unit pyramid, the pyramid $(10\bar{1}4)$ would have an angle of 29° 10′.

A crystal, bent like that figured by Knop so that the ridges divided the cleavage into three areas not in the same plane, yielded an angle of 76° 59′ between a pyramidal plane and the adjacent portion of the cleavage.

For $(20\bar{2}1)$ the angle 77° 13′ has been calculated.

5. *Molybdenite from the Tilly Foster Iron Mine, Brewsters, N. Y.*

Mr. F. V. Cruser presented the Egleston Museum with some specimens of molybdenite found by him at the mine. They occur in a cleavable calcite associated with small bright crys-

tals of green amphibole. On one crystal showing four faces of a pyramid two adjacent faces intersected in an edge which permitted careful adjustment on the Fuess goniometer. Each yielded a bright image of the signal which was only slightly distorted horizontally. The five readings of each face varied with respect to the mean, to the nearest half minute as follows:

First.	Second.
$-14\frac{1}{2}$	$+0\frac{1}{2}$
$+\ 4\frac{1}{2}$	$-6\frac{1}{2}$
$+\ 8\frac{1}{2}$	$-8\frac{1}{2}$
$+\ 6\frac{1}{2}$	$+6\frac{1}{2}$
$-\ 5\frac{1}{2}$	$+8\frac{1}{2}$

The angle obtained was 54° 08′, which corresponds to an angle with the cleavage of 65° 31′. The angle for $(10\bar{1}1)$ on the Frankford, Pa., crystals is 65° 35′.

6. *Molybdenite from Warren, N. H.*

In an old suite of molybdenite specimens in the Egleston Museum I found a number of small doubly terminated crystals three of which gave with the hand goniometer for all faces an angle with the cleavage between 54° and 55°. The pyramidal faces were striated and most of them curved and the cleavage was curved.

One crystal (fig. 4) showing twelve pyramidal planes was roughly oriented on the two-circle goniometer by the bent cleavage. Three faint signals were obtained with ϕ respectively 60°, 120° and 240°, which were approximately $\rho = 90°$. The crystal was then readjusted until these signals were accurately $\rho = 90°$.

The results were analogous to those obtained with the Aldfield crystal, that is images of the collimator signal were obtained for two different positions, each of which corresponded to a general illumination of the surface. In this case, however, both corresponded to oblique angles (pyramids). The results were

ϕ	ρ		ρ
0°	55° 15′	Two images	64° 36′
60	54 30	Bright image	64 58
119 06′	- - - -		
180 24	Blur		
240 20	54 25	Blurred image	64 18
Average	54° 43′		64° 27′

The simplest interpretation of these angles is that they correspond to $(20\bar{2}3)$ and $(10\bar{1}1)$, for which the corresponding calcu-

lated angles are 55° 45′ and 65° 35′. *Relatively* they are fairly close to calculated angles, for a unit angle of 64° 27′ would require for (20$\bar{2}$3) an angle of 54° 21′. It is not unreasonable to suppose an error in orientation or in the reading of the faint prismatic signals which would diminish both angles about the same amount.

The conclusion, therefore, is a dominant pyramid (20$\bar{2}$3) with striations due to an oscillation between this and (10$\bar{1}$1); the prism (10$\bar{1}$0) present as a slightly developed modification.

7. *The Knop and Hörnes Measurements.*

The crystals from Auerbach, Hesse, examined by Knop,* were parallel plates often with curved lamellæ. No regular twin striations but frequent wrinkling which appeared to be perpendicular to the sides of the hexagon producing approximations to rhombic thirds of faces. Measurements did not give any constant angles between these 'thirds,' which were evidently results of bending or wrinkling.

Although, as might be expected, these bent crystals gave no constant angles,† it is noteworthy that the averages both of the angles with the cleavage and the angles between adjacent faces closely approach those of the unit pyramid.

	Adjacent faces.	Faces with cleavage.
	50° 07′	71° 0′
	56 49	69 04
	56 37	57 20
Average	54° 31′	65° 48′

The Frankford, Pa., unit pyramid (10$\bar{1}$1) has angles respectively 54° 10′ and 65° 35′.

With respect to the crystals from Greenland, Hörnes states: "I have measured the crystals from Narksak and found the pyramid 123° 45′, 140° 57′."‡ Kenngott reëxamined§ the crystals and accepted the proof of their hexagonal form but pronounced the pyramid dubious, attributing it to the slipping of curved prisms and to tapering, but states, "one small crystal only showed a fairly distinct acute hexagonal pyramid."

Hintze‖ gives these angles as $pc = 70° 28\frac{1}{2}'$ and $pp = 56° 15'$. There appears to have been a slight error here, as for $pp = 56° 15'$, $pc = 70° 31\frac{1}{4}'$. This corresponds to (50$\bar{5}$4), for which the calculated angle is 70° 03′.

* Summarized from Neues Jahrb. f. Min., 1848, p. 43.
† Obtained by attaching mica to the faces.
‡ Uebersicht Darstell. des Mohsischen Min. Syst., 1847, p. 115.
§ Min. Forschungen, 1856, p. 104. ‖ Mineralogie, vol. i, p. 104.

Summary of Molybdenite Measurements.

Assuming the unit of Brown, viz., a pyramid *o* making an angle *co* with the cleavage equal 65° 35′ from which $\dot{c} = 1{\cdot}908$ is calculated, the observations may be summed up as follows: the angles with the cleavage being given.

Basal pinacoid, *c* (0001). Not observed except possibly on Enterprise, Ont. crystal.

Prism, *m* (10$\bar{1}$0). Frankford, Pa., sometimes prominent, Aldfield, Quebec, as part of striations; Warren, N. H., traces.

Pyramid, *q* (30$\bar{3}$1). Calculated angle 81° 24′.
Observed at Frankford, Pa. Measured angle 81° 31′.

Pyramid, *p* (20$\bar{2}$1). Calculated angle 77° 13′.

Measured angles	Frankford, Pa.	77° 15′
	Aldfield, Quebec	77 18
	Cape Breton	77 29
	Okanogan Co., Washington	76 59

Pyramid, *r* (50$\bar{5}$4). Calculated angle 70° 03′.
Observed at Narksak, Greenland. Measured angle 70° 31½′.

Pyramid, *o* (10$\bar{1}$0). Unit angle, Frankford, Pa., 65° 35′.

Measured angles	Tilly Foster Mine	65° 29′
	Auerbach, Hesse	65 48
	Warren, N. H.	64 27

Pyramid, *t* (20$\bar{2}$3). Calculated angle 55° 45′.
The Warren, N. H., angles for this, 54° 43′, and unit are *relatively* close for these indices but low for the Brown unit.

Pyramid, *s* (20$\bar{2}$5). Calculated angle 41° 23′.

Measured angles	Enterprise, Ontario	41° 26′
	Okanogan Co., Washington	41 46

Pyramid, *u* (10$\bar{1}$4). Calculated angle 28° 51′.
On Okanogan Co., Wash., the angle 29° 54′ was obtained, which was near these indices for 20$\bar{2}$5 = 41° 46′.

Columbia University, January, 1904.

ART. XXXIII.—*The Behavior of Typical Hydrous Chlorides when heated in Hydrogen Chloride;* by F. A. GOOCH and F. M. McCLENAHAN.

(Contributions from the Kent Chemical Laboratory of Yale University—CXXVI.)

THE halogen salts of the metals are convertible by the action of water to oxy-salts, hydroxides, or oxides with varying degrees of readiness. In order that water may act hydrolytically upon barium chloride, for example, with liberation of hydrogen chloride and substitution of oxygen for chlorine, the temperature of the system must approach low redness, while magnesium chloride is attacked at a much lower temperature, and aluminum chloride is extremely sensitive to the metathetical action of water. These reactions follow the indications of the heat moduli of the transformations. To effect the metathesis between barium chloride and water, with formation of barium hydroxide and hydrogen chloride, a very considerable accession of energy from without the system is needed; the similar reaction between magnesium chloride and water requires less reinforcement from the outside; while the reaction between anhydrous aluminum chloride and water takes place easily. When a hydrous chloride is heated to the temperature of decomposition, the products will be the anhydrous chloride and water, or hydrogen chloride and an oxychloride, oxide or hydroxide, according to the nature of the particular chloride under experimentation. Hydrous barium chloride, $BaCl_2 \cdot 2H_2O$, parts with all its water and becomes anhydrous at 100° C.; the hydrous magnesium chloride, $MgCl_2 \cdot 6H_2O$ may lose a large part of its water at temperatures considerably above 100° without appreciable loss of chlorine, but exchanges chlorine for oxygen with formation of hydrogen chloride at higher temperatures; while hydrous aluminum chloride, $AlCl_3 \cdot 6H_2O$, loses water only with simultaneous formation of hydrogen chloride and exchange of chlorine for oxygen at 100°, and at temperatures at which all water is removed is converted to aluminium oxide.

It is obvious that in those cases in which hydrolytic decomposition takes place at temperatures below those at which the tendency to reversal ceases, the rate of decomposition must be affected by the concentrations of the active products of decomposition. So it is natural to expect that an increase in the concentration of hydrogen chloride in the system will serve to restrain hydrolytic action and decomposition of the chlorides at temperatures of incipient hydrolysis. Dumas* tried to take advantage of this principle in the preparation of anhydrous magnesium chloride, free from oxide, by prolonged drying of

* Ann. Chim. (3), lv, 187.

the hydrous chloride in an atmosphere of hydrogen chloride, but at the temperature of incipient redness at which Dumas worked the reversal of the hydrolytic effect is slow and difficult.

In the case of a hydrous chloride, like barium chloride, which shows no tendency to undergo hydrolytic decomposition at temperatures at which the water is completely removed, there seems to be no reason for anticipating any marked effect upon the progress of the dehydration when hydrogen chloride is made the surrounding atmosphere instead of air. With a hydrous chloride which evolves hydrogen chloride at the temperature of dehydration and forms an oxychloride, oxide or hydroxide the case is different. In such a case the effect of enormously increasing the concentration of hydrogen chloride in the system at the temperatures of incipient hydrolysis will naturally be to restrain the hydrolysis; but whether the result will be the formation of a chloride of lower content of water or an increased stability of the hydrous chloride for some range of temperature will turn upon the affinity of the anhydrous chloride for water.

In the process of dehydrating hydrous aluminum chloride, for example, an increase in the concentration of hydrogen chloride in the system will tend to retard the exchange of hydroxyl for chlorine at the temperature of incipient hydrolysis; but whether the result of such retardation will be the formation of the anhydrous chloride or simply an extension of the range of temperature for which the original hydrous chloride is stable is not immediately obvious, though the high degree of attraction existing between anhydrous aluminum chloride and water, as indicated in the large heat of hydration of that salt, would seem to suggest the latter alternative.

In the work of which an account follows the effect of substituting an atmosphere of hydrogen chloride for ordinary air in experiments upon the dehydration of typical hydrous chlorides was studied. Barium chloride as the representative of salts which lose water without other decomposition, magnesium chloride which suffers some loss of chlorine when fully dehydrated, and aluminum chloride which loses all its chlorine when similarly dehydrated, were the hydrous chlorides taken for these experiments.

In these experiments two combustion tubes of large size set horizontally side by side in a tubulated paraffine bath served as heating chambers. Each tube was fitted with a thermometer and connected through a drying bulb and column with an aspirator. Portions of the hydrous chloride to be treated were weighed into porcelain boats. One of these boats was inserted in each tube about midway in the bath (heated to a regulated temperature) and immediately below the bulb of the thermom-

eter, so that the temperature of the material in the boat might be indicated by the thermometer as nearly as possible. Through one tube was drawn slowly a current of air purified by caustic potash and sulphuric acid, and through the other was sent a slow current of hydrogen chloride, generated in a Kipp generator by the action of sulphuric acid upon sublimed ammonium chloride in lumps. At the expiration of a definite period, the boat was withdrawn, placed in a desiccator and weighed after a suitable interval for cooling. The residue in the boat was dissolved in water, acidulated with nitric acid and the chlorine in it was precipitated by silver nitrate, the silver chloride being weighed on asbestos. Thus it was possible to determine directly the loss of water and chlorine from individual portions of the salt under experimentation during definite intervals and at fixed temperatures, both in an atmosphere of hydrogen chloride and in air, and to find for each individual portion under experiment what proportion of the total loss was hydrogen chloride and what was water. The tabular statements and the diagrams show the course of decomposition of the various salts for the temperatures indicated.

Hydrous Barium Chloride.

For the experiments with barium chloride a well-crystallized specimen showing by analysis a normal content of chlorine was taken. During the process of dehydration at temperatures ranging as high as 100°, at which point all water was expelled, there is no evidence of loss of chlorine, and the course of dehydration, as would be anticipated, appears to be wholly uninfluenced by the presence of hydrogen chloride.

The slight increase in the chlorine generally found in the salt after exposure to the atmosphere of hydrogen chloride may be properly attributed to occlusion or adsorption of hydrogen chloride. The data of individual experiments are gathered in Table I, p. 368, and the general course of action is followed in the diagram.

Hydrous Magnesium Chloride.

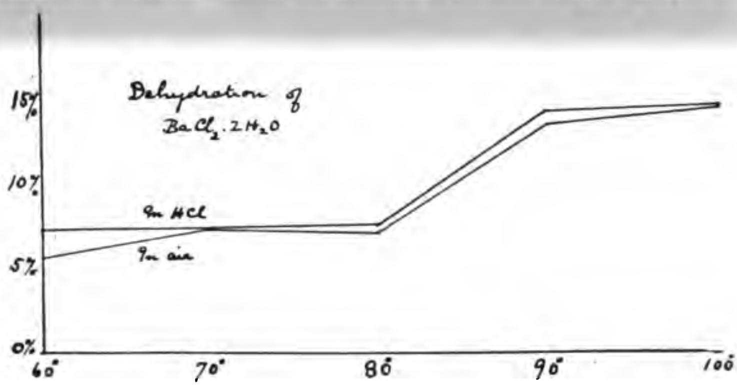
Similar experiments, the data of which are given in Table II, were made with hydrous magnesium chloride dried *in vacuo* over sulphuric acid and of nearly ideal constitution.

So far as these results go, it appears that the loss of chlorine during the process of dehydration of the hydrous magnesium chloride, $MgCl_2 \cdot 6H_2O$, is generally small until a temperature approximating 200° is reached; that at temperatures between 100° and 130° hydrogen chloride generally restrains dehydration, while above that temperature dehydration progresses more

TABLE I.

Ba	56·24
Cl_2	29·02
$2H_2O$	14·74
	100·00

Atmosphere.		Weights taken. grm.	Loss on heating.		Chlorine in residue.			Water evolved. Per cent.	Time. hrs.	Temperature.
			grm.	Per cent.	grm.	Per cent.	Variation from theory.			
1	Air	0·3335	0·0189	5·67	0·0969	29·06	+0·04	5·67	½	60°
	HCl	0·2952	0·0205	6·94	0·0866	29·34	+0·32	7·27	½	
2	Air	0·3609	0·0262	7·26	0·1045	28·96	−0·06	7·20	½	70°
	HCl	0·3004	0·0213	7·09	0·0875	29·13	+0·11	7·21	½	
3	Air	0·2919	0·0206	7·06	0·0848	29·05	+0·03	7·09	½	80°
	HCl	0·3362	0·0243	7·23	0·0981	29·18	+0·16	7·39	½	
4	Air	0·4161	0·0557	13·38	0·1207	29·01	−0·01	13·37	½	90°
	HCl	0·2972	0·0389	13·09	0·0894	30·08	+1·06	14·18	½	
5	Air	0·4904	0·0711	14·49	0·1423	29·02	0·00	14·50	½	100°
	HCl	0·4272	0·0630	14·75	0·1236	28·93	−0·09	14·64	½	



rapidly in the presence of hydrogen chloride. Hydrogen chloride appears to influence in no very marked and regular way the loss of the first third of the water.

TABLE II.

Mg	11·98
Cl_2	34·87
$6H_2O$	53·15
	100·00

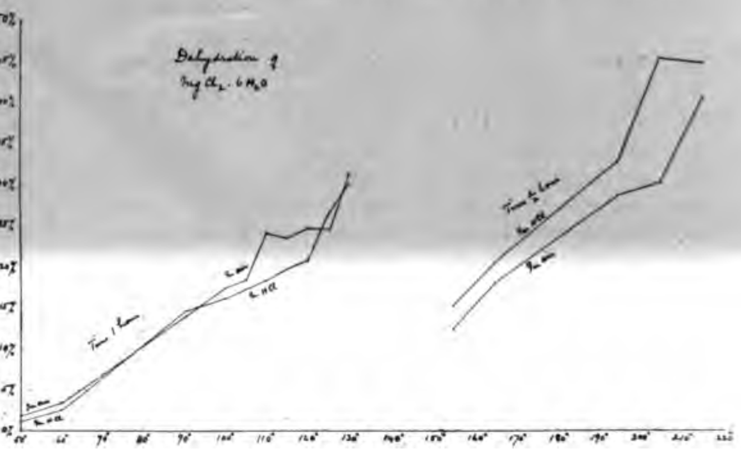
	Atmosphere.	Weight taken. grm.	Loss on heating. grm.	Loss on heating. Per cent.	Chlorine in residue. grm.	Chlorine in residue. Per cent.	Chlorine in residue. Variation from theory.	Water evolved. Per cent.	Time. hrs.	Temperature. C°.
1	Air	0·5004	0·0093	1·85	....	....	....	1·85	1	50
	HCl	0·4330	0·0046	1·06				1·06		
2	Air	0·5139	0·0181	3·52	0·1781	34·66	− ·21	3·31	1	60
	HCl	0·4310	0·0110	2·55	0·1503	34·87	·00	2·55		
3	Air	0·7281	0·0387	5·31	....	....	....	....	1	70
	HCl	0·6093	0·0240	3·93						
4	Air	0·7193	0·1026	14·26	0·2483	34·52	− ·35	13·90	1	90
	HCl	0·6183	0·0900	14·55	0·2155	34·85	− ·02	14·51		
5	Air	0·2854	0·0497	17·41	0·9913	34·79	− ·08	17·33	1	100
	HCl	0·2453	0·0405	16·51	0·8486	34·60	− ·27	16·23		
6	Air	0·5036	0·0927	18·41	0·1755	34·85	− ·02	18·39	1	105
	HCl	0·4591	0·0799	17·40	0·1599	34·83	− ·04	17·36		
7	Air	0·6679	0·1611	24·12	0·2327	34·84	− ·03	24·09	1	110
	HCl	0·5012	0·0908	18·11	0·1750	34·91	+ ·04	18·15		
8	Air	0·5893	0·1404	23·82	0·2055	34·87	·00	23·82	1	115
	HCl	0·5145	0·1018	19·78	0·1801	35·00	+ ·13	19·91		
9	Air	0·5012	0·1314	26·21	0·1678	33·48	−1·39	24·78	1	120
	HCl	0·4542	0·0944	20·78	0·1586	34·92	+ ·05	20·83		
0	Air	0·4249	0·1043	24·55	0·1480	34·85	− ·02	24·53	1	125
	HCl	0·4176	0·1104	26·44	0·1461	34·99	+ ·12	26·56		
1	Air	0·4891	0·1511	30·89	0·1721	35·19	+ ·32	31·21	1	130
	HCl	0·3662	0·1093	29·85	0·1283	35·04	+ ·17	30·02		
2	Air	0·3583	0·0452	12·61	0·1240	34·61	− ·16	12·45	½	155
	HCl	0·3300	0·0503	15·24	0·1151	34·88	+ ·01	15·25		
3	Air	0·3918	0·0716	18·27	0·1359	34·69	− ·18	18·09	½	165
	HCl	0·3964	0·0811	20·46	0·1376	34·71	− ·16	20·30		
4	Air	0·3618	0·1057	29·21	0·1240	34·27	− ·60	28·59	½	195
	HCl	0·3695	0·1225	33·15	0·1278	34·59	− ·28	32·86		
5	Air	0·3330	0·1079	32·40	0·1091	32·76	−2·11	30·13	½	205
	HCl	0·3209	0·1426	44·44	0·1143	35·62	+ ·75	45·21		
6	Air	0·2728	0·1156	42·38	0·0906	33·20	−1·67	40·66	½	215
	HCl	0·3583	0·1671	46·64	0·1179	32·90	−1·97	44·61		

Hydrous Aluminum Chloride.

Pure hydrous aluminum chloride, $AlCl_3 \cdot 6H_2O$, was made by dissolving the C. P. hydrous chloride of the laboratory in the least possible amount of aqueous hydrochloric acid, filtering the solution through asbestos, and saturating the clear solution with gaseous hydrogen chloride. The crystallized chloride thus obtained was collected on asbestos in a perforated cone,

washed with concentrated hydrochloric acid, sucked as dry as possible by the pump, and exposed seventy-two hours in a desiccator containing quicklime, to absorb free hydrogen chloride, as well as sulphuric acid to take up water. The composition of the product was fixed by determining the aluminum as the oxide by ignition with mercuric oxide,* and the chlorine by precipitation with silver nitrate, as shown in the following analyses:

	Analysis I.	Analysis II.	Theory for $AlCl_3 \cdot 6H_2O$.
Aluminum	11·17	11·21	11·20
Chlorine	43·92	44·18	44·05
Water (by difference)	44·91	44·61	44·75
	100·00	100·00	100·00



Weighed portions of this preparation lost practically nothing in three weeks at the ordinary temperature over sulphuric acid, calcium chloride, and phosphorous pentoxide, and remained almost unchanged when heated to 98°.

The details of two parallel series of experiments in which portions of the hydrous aluminum chloride were heated in air or in a current of hydrogen chloride are recorded in Table III, and the course of the change in weight and loss of chlorine at various temperatures in air and in hydrogen chloride are shown in the diagram.

From the results of these experiments it appears that the inhibitive action of the atmosphere of hydrogen chloride upon the dehydration of hydrous aluminum chloride is marked at the lower temperatures. While the hydrous salt when heated in

* Gooch and Havens: This Jour. vi, 45 (1898).

TABLE III.

Al	11·20	per cent
Cl_3	44·05	"
$6H_2O$	44·75	"
	100·00	

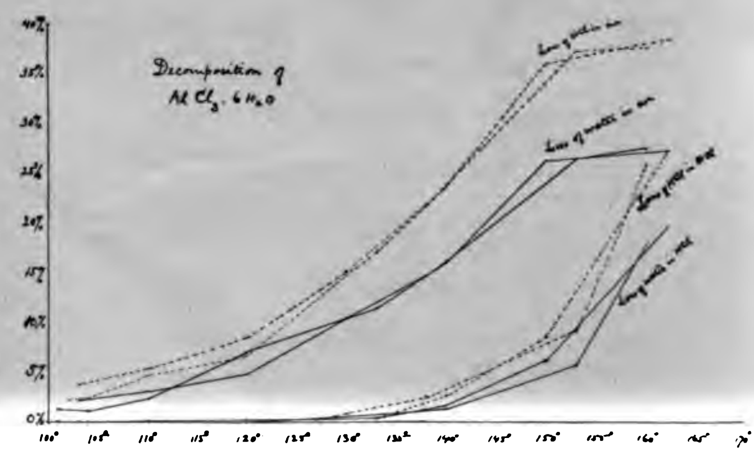
Series I.

os- e.	Weight taken. grm.	Loss on heating. grm.	Loss on heating. Per cent.	Chlorine in residue. grm.	Chlorine in residue. Per cent.	HCl lost. Per cent.	Water lost. Per cent.	Time. hrs.	Temperature. C°.
r	0·3745	0·0123	3·28	0·1571	41·96	2·15	1·13	1	101
Cl	0·4419	0·0006	·13	----	----	----	----		
r	0·4314	0·0145	3·36	0·1801	41·75	2·36	1·00	1	104
Cl	0·3725	0·0006	·16	----	----	----	----		
r	0·3719	0·0261	7·02	0·1467	39·44	4·74	2·28	1	110
Cl	0·4413	0·0008	·18	----	----	----	----		
r	0·3225	0·0446	13·83	0·1206	37·39	6·84	6·97	1	120
Cl	0·3141	0·0010	·32	----	----	----	----		
r	0·3725	0·1064	28·56	0·1022	27·43	17·08	11·48	1	133
Cl	0·4583	0·0020	·43	----	----	----	----		
r	0·5664	0·2254	39·80	0·1182	20·87	23·82	15·98	1	140
Cl	0·4503	0·0207	4·60	0·1860	41·30	2·83	1·77		
r	0·3503	0·2185	62·38	0·0318	9·08	35·99	26·39	1	150
Cl	0·2563	0·0382	14·90	0·0911	35·54	8·75	6·15		
r	0·3085	0·2033	65·89	0·0202	6·55	38·56	27·33	1	162
Cl	0·5230	0·2441	46·67	0·0930	17·78	27·01	19·66		

Series II.

r	0·2292	0·0135	5·89	0·0926	40·40	3·75	2·14	1	103
Cl	0·2425	0·0000	----	----	----	----	----		
r	0·2855	0·0234	8·20	0·1113	38·97	5·21	2·99	1	110
Cl	0·3139	0·0002	·06	----	----	----	----		
r	0·3640	0·0482	13·24	0·1307	35·97	8·37	4·87	1	120
Cl	0·2860	0·0005	----	----	----	----	----		
r	0·2346	0·0596	25·40	0·0687	29·36	15·10	10·30	1	130
Cl	0·2437	0·0022	·90	----	----	----	----		
r	0·4178	0·1543	36·93	0·0944	22·59	22·04	14·89	1	138
Cl	0·2984	0·0117	3·92	0·1241	41·59	2·53	1·39		
r	0·3375	0·2159	63·97	0·0260	7·70	37·37	26·60	1	153
Cl	0·3583	0·0539	15·04	0·1258	35·11	9·19	5·85		
r	0·2425	0·1607	66·27	0·0154	6·35	38·75	27·52	1	160
Cl	0·2512	0·1105	43·99	0·0472	18·79	25·97	18·02		

air loses water appreciably at 101°, the loss in an atmosphere of hydrogen chloride is not considerable until the temperature rises to about 130.° In both cases, however, loss of weight is accompanied by hydrolytic action. At the outset, for every gram-molecule of water liberated approximately a gram-molecule of hydrogen chloride is eliminated: later the proportion of water to the hydrogen chloride increases, because, no doubt, the aluminum hydroxide first formed begins to lose water.



Discussion of Results.

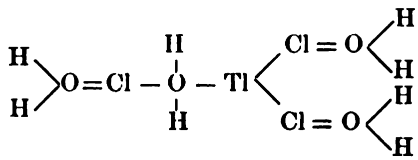
It appears that hydrogen chloride is without influence of any kind in the dehydration of hydrous barium chloride, $BaCl_2 \cdot 2H_2O$, at temperatures not exceeding 100°, at which the process is complete.

In dehydrating hydrous magnesium chloride, $MgCl_2 \cdot 6H_2O$, hydrogen chloride appears to have little or no effect upon the loss of the first third of the water (which may be removed at 100°), to act in restraint of the process of dehydration when the salt is placed at once in an atmosphere heated to a point between 100° and 130°, and to aid dehydration at temperatures above 130°. The hydrolytic dissociation of the salt is not very marked in either air or hydrogen chloride until the temperature approaches 200°.

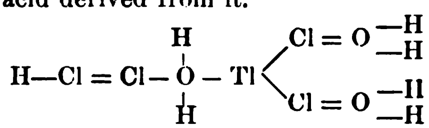
The dehydration of aluminum chloride, $AlCl_3 \cdot 6H_2O$, is inhibited by an atmosphere of hydrogen chloride until a temperature of about 130° is reached. Above that point, as in air above 100°, water and hydrogen chloride are evolved simultaneously.

In attempting to account for the relation of water of crystallization to the general molecular configuration of hydrous

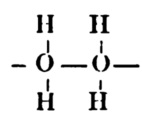
rides, Cushman* has proposed to make use of the hypothe-)f quadrivalent oxygen in a way to show linkings of nger and weaker combination. Those molecules of water :h are held more firmly than others are placed within the ecular complex, while those molecules of water which it of easy removal without affecting the constitution of the ydrous salt are attached externally. According to Cush- , the hydrous thallic chloride may be represented by the bol



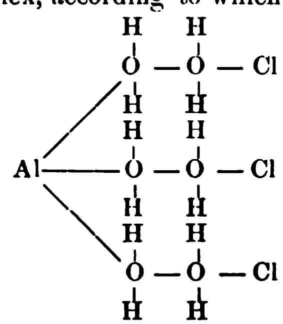
ch by placing a single molecule of water within the com- : brings to view the observed fact that at the ordinary ospheric temperatures one molecule of water is held more ly than the other three. The easy transformation of this by the action of hydrochloric acid, as observed by Meyer,† is ibited by a comparison of the symbol with that of the rthallic acid derived from it.



the molecule of hydrous aluminum chloride Cushman :es the suggestion that the water is held in three linkages



nin the complex, according to which the symbol would be



* Am. Chem. Jour., xxvi, 505. † Loc. cit.

This symbol brings out the experimental fact that water cannot be eliminated without simultaneous liberation of hydrogen chloride, at least in the first reaction, and shows that from a molecule thus constituted the formation of aluminum hydroxide or oxide with evolution of water and hydrogen chloride would seem to be natural.

A little consideration makes it obvious, however, that the decomposition of a molecule containing the group

$$\begin{array}{ccccc} & H & & H & \\ & | & & | & \\ - & O & - & O & -Cl \\ & | & & | & \\ & H & & H & \end{array}$$

need not in every case result finally in the elimination of all chlorine as hydrochloric acid and the formation of the metallic hydroxide, oxyhydroxide, or oxide. When conditions favor, there would seem to be nothing to prevent more or less secondary reaction of the liberated hydrogen chloride upon the metallic hydroxide first produced. Whether such secondary reaction will take place in any given case will depend largely upon the relative strengths of affinities of which we have, at least in many cases, some sort of measure in the heats of reaction.

It is not likely, for example, that the reaction of hydrogen chloride upon aluminum oxide with formation of aluminum chloride and gaseous water will take place to any considerable degree when the heat of such reaction would be negative to the extent of approximately 27,000 cal. for every gram-molecule of aluminum oxide converted. On the other hand, it is not unreasonable to look for some convertion of magnesium oxide to magnesium chloride by a reaction which involves the liberation of approximately 19,000 calories to the gram-molecule of magnesium oxide attacked. So it appears that an inner linkage such as is suggested by Cushman might possibly exist in the case of such a salt as hydrous magnesium chloride without coming very much into evidence by reason of the evolution of hydrogen chloride and formation of magnesium hydroxide or oxide when the salt is heated.

Turning now to the consideration of what is likely to occur when a molecule possessing the linking

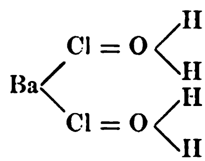
$$\begin{array}{ccccc} & H & & H & \\ & | & & | & \\ - & O & - & O & - Cl \\ & | & & | & \\ & H & & H & \end{array}$$

is heated in presence of hydrogen chloride, it is obvious that the first effect of increasing the concentration of hydrogen

chloride at the temperature of incipient decomposition would be to reverse the action of decomposition and to hold the hydrous salt in a condition of greater stability. In the case of a salt which when heated evolves all its chlorine this inhibitive action would be the only effect observed. In the case of salts which give in the decomposition hydroxides or oxides capable of reacting with hydrogen chloride under the conditions with the formation of an anhydrous chloride, the effect of heating in an atmosphere of hydrogen chloride might also be increased stability for a certain range of temperature, but this limit of stability once passed, a second effect of the hydrogen chloride tending to increase the rapidity of the formation of the anhydrous chloride and so to produce a more rapid evolution of water from the salt as compared with the amount of water set free from the salt heated *per se* at the same temperature might become prominent. It is to be expected that one and the same salt might exhibit each of these effects, the one restraining dehydration and the other aiding it, at appropriate temperatures.

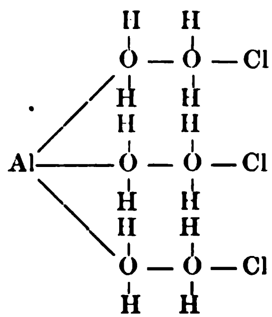
Now, returning to the salts under investigation, we find that the experimental results fall very well into line with the assignment of symbols according to Cushman's hypothesis.

The symbol



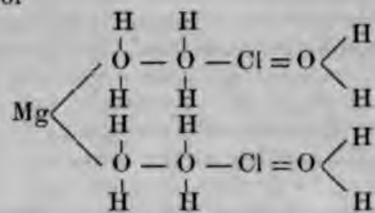
suggests the observed easy detachment of water and the absence of all effect of decomposition of the chloride when the water is removed at 100°, and suggests no reason why any special effect should be anticipated when hydrogen chloride is made the medium in which dehydration takes place.

The symbol



indicates the experimental fact that water cannot be removed from the salt without simultaneous breaking out of hydrogen chloride at least in the primary action, and suggests that increase in the concentration of hydrogen chloride in the system should retard the dehydration of the salt, as was observed.

The symbol



shows that one-third of the water in the salt should be evolved easily and without hydrolytic effect. Thereafter, the atmosphere of hydrogen chloride will act to increase the stability of the chloride now containing four molecules of water within the complex and so to limit the rate of dehydration as compared with that in air for some range of temperature, as was observed between 100° and 130°. The limit of increased stability once passed, the rate of dehydration will depend upon the predominance of the primary effect of decomposition with liberation of water and hydrogen chloride or of the secondary action of hydrogen chloride upon the residual oxide or hydroxide. In case the secondary effect predominates, the rate of dehydration will be greater in the atmosphere of hydrogen chloride, as it was in six out of seven experiments at temperatures between 120 and 215°.

So it appears, that the phenomena of dehydration of the hydrous chlorides under discussion, in the atmosphere of hydrogen chloride as well as when heated *per se*, find reasonable expression upon the hypothesis of varying relations of position of the water within the molecular complex, as suggested by Cushman upon the assumption of quadrivalent oxygen. The behaviour of hydrous chlorides in an atmosphere of hydrogen chloride should in many cases afford means of differentiating the water within the complex from water attached externally.

ART. XXXIV.—*On Stegomus Longipes, a New Reptile from the Triassic Sandstones of the Connecticut Valley;* by B. K. EMERSON and F. B. LOOMIS. (With Plate XXII.)

IN spite of the great abundance of tracks preserved in the Triassic sandstones of the Connecticut valley indicating a rich land fauna, the number of osseous remains is limited to three dinosaur specimens and a portion of an Aëtosaurus-like carapace, called by Marsh, Stegomus*. On account of this rarity, the appearance of a new fossil throwing light on the land fauna, and on the makers of the well known tracks, is of general interest.

Some seven years ago, while removing the superficial layers of sandstone in the Hines Quarry, which is about a mile east of the village of East Longmeadow, Mass., Mr. G. B. Robinson found the small lizard-like specimen which is the subject of this paper. It occurred in a dense layer of red sandstone some ten feet below the surface and immediately above the thicker and softer layers which are used commercially for building stone. The discoverer removed the blocks containing the animal to his door yard, where they remained for about seven years exposed to the weather. They were seen by Mr. and Mrs. E. D. White, who obtained possession of them and brought the fossil to Springfield. Mr. and Mrs. White kindly placed this finely preserved fossil at our disposal for study and description.

The specimen consists of three pieces containing the major part of the whole animal. All but a thin interrupted film of the bone has been leached out, leaving spaces which are filled with calcite. It is, then, largely a cast, both the upper and lower surfaces of the bone being impressed on one block or the other. The first block contains most of the fossil, the splitting having exposed the under surface of the bones roofing the head, of the carapace from the head to the pelvis (28 pairs of plates), the bones of the right arm and left foot. The second block contains the impression of the upper surface of the same parts. The third is a chip, flaked off just in front of the pelvis and exposing the vertebræ of that region.

Skull.—This is broadly triangular in outline, tapering to a pointed snout. The upper surface of the cranium seems to have been completely roofed with bone, except possibly directly over the orbit. Two supraorbital bones are distinctly indicated, but between them and the frontals is a space which seems to have been open (see *l* in fig. 2, Pl. XXII). Sutures are present

* Marsh, O. C., 1896, this Journal (4), ii, pp. 59–62.

showing that the dermal bones were paired along the middle line. The premaxillæ are short, the nasals are rather long, but the boundaries of the other bones cannot be made out. A vertical break shows the side of the skull imperfectly, as restored in fig. 3, Pl. XXII. The parts actually present are indicated by the complete line, while restoration is indicated by a broken line. It is a low skull, being about one-third as deep as long. The quadratum is well back, making a long jugal arch. An antorbital vacuity is present though its boundaries are very imperfectly indicated. The orbit is moderately large, being distinctly bounded off from the temporal vacuities as indicated. It has above it at least two supraorbital bones. That there is a large lateral temporal vacuity is certain. A forward projection of bone in the squamosal region seems to indicate a dividing arcade between this and a supra-temporal vacuity, but the arcade is not complete and is not therefore certain. On the maxilla of the left side one tooth and a part of a second is preserved, showing them to be tiny conical affairs. The depth of the lower jaw is about 3^{mm}, being a light slender mandible.

Carapace.—The dorsal side of the body was protected by a double row of plates, on either side. Those along the middle line are wide, their outer edges being flanked with small quadrate scutes. From the head to the pelvis there are 28 sets of plates, which are narrow and inflexed in the neck region, widen till the middle of the body is reached, and then gradually taper toward the tail. The arrangement and relations of these scutes are seen in fig. 2. Each plate of the median row is usually about 4–4 $1{\cdot}2^{mm}$ from front to back. The third and fourth, however, are about half as wide as the rest, while the fifth is much the widest, being wider than the two preceding taken together. Possibly some of this variation is due to the curvature of the neck, but most of it is clearly the bone itself. The rear margin of each scute overlapped the front of the succeeding one, as is clear in the cast of the upper surface. Marsh considered that in his specimen this was not the case, but the fossil shows only the under surface of the scutes and they appear exactly as do those in the specimen under description. Marsh used this character to distinguish Stegomus from Aëtosaurus, but the contrasts must be found in other characters, as is shown later. Along the outer margins of plates 5–9 small quadrate scutes were brought into sight by preparation. The nature of the fossil does not permit further preparation, but doubtless similar scutes occur all along the side of the body. On the cast of the upper surface of the scutes, there are indications that the surface was pitted but the coarseness of the sandstone prevents certainty.

Vertebræ.—Three presacrals are exposed, each deeply bicon-

cave and with long transverse processes. Two vertebræ only are involved in the sacrum, their moderately long transverse processes supporting the ilium. How completely they are united is not clear on account of the broken condition of the vertebræ, but they appear slightly separated. Three and a half deeply biconcave caudals are all that are preserved. The transverse processes of these are even longer than on the presacrals and quadrate in section. From the sacrum back they are progressively longer, suggesting a broad flat tail such as is known for Aëtosaurus.

Fore Limb.—Of the pectoral girdle only the scapula is present, and this is a broad triangular bone 9^{mm} long by 5^{mm} deep. Its upper margin lies parallel to small lateral plates 7–9 in the series. The leg is unusually long, the slender humerus being $1\frac{1}{2}^{mm}$ in diameter and 24^{mm} in length, a bone nearly straight and swelling slightly at either end. The radius and ulna are but $\frac{3}{4}^{mm}$ in diameter and 19^{mm} long. As the specimen lies, the radius crosses the ulna, but whether this indicates great flexibility or is mere chance is not to be determined. The fore foot is lacking.

Hind Limb.—An ilium 12^{mm} long, the front and rear ends of which curve strongly outward, is present, but only its rough outline is to be made out. Of the limb bones only short fragments are discernible, where they are broken across; but enough is visible to show the direction and diameter of the bones, and by extending these the length can be approximately found. This indicates a leg slightly longer than the fore leg. The femur was $1\frac{1}{2}^{mm}$ in diameter and 26^{mm} in length (by reconstruction). The tibia and fibula are each about the same size, $\frac{3}{4}^{mm}$ in diameter and 21^{mm} long (by reconstruction). The left foot is well preserved. The individual tarsals are not to be made out. Four toes are well preserved, but a fifth is nowhere even indicated. The length of the toes on the figure is probably a little short, as each seems incomplete at the end. The metapodials are long, but the details of the toes do not come out with certainty, though a slight widening at intervals was taken to indicate the joints, and they are drawn on that supposition.

Comparison.—This animal resembles most closely Marsh's *Stegomus arcuatus*, of which twenty dorsal sets of plates are described. It is a much smaller species and presents most of the important features, thus allowing a conception of the animal and its relationships. *Stegomus longipes* is about one-third the size of the preceding species, which is the only comparison readily made, as Marsh's fossil is so incomplete. It belongs to the Aëtosauridæ* and resembles that genus in many important features, but there are enough characters of weight to demand a separate genus, as established by Marsh. Ornitho-

* Fraas O. 1877, Württemb. naturw. Jahreshefte, xxxiii, Festschrift.

suchus and Erpetosaurus of Newton* also have some features resembling *S. longipes* but are far wider differentiated than the German genus. Aëtosaurus has about twenty-five sets of plates from the head to the pelvis, each consisting of a median pair of large scutes and small quadrate scutes outside these. Stegomus has about twenty-eight exactly similar sets of plates.

In the skull, however, there are marked contrasts. The orbit of both genera is bounded above by extra supraorbital bones, but the orbit of the Aëtosaurus is further back than that of Stegomus: the result of which is that the former has only a single small supra-temporal vacuity, while the latter has at least a very large vacuity, and possibly that divided into a supra-temporal and a lateral temporal vacuity. The Stegomus has a wider skull and above the orbit a vacuity or at least a deep depression. The vertebræ of Aëtosaurus are procœlous, while those of Stegomus are amphicœlous. Ornithosuchus has platycœlous vertebral centra. The sacrum in the other known Aëtosauridæ includes three vertebræ, but in Stegomus only two are united to the ilium. Both the fore and hind limbs of Stegomus are much longer and more slender than the Aëtosaurus, this being the character which has suggested the specific name longipes.

The features above described show this fossil to be the remains of a small armoured lizard-like creature, with long legs. It seems to be a land form and of extreme agility.

The following are the measurements of the principal parts:

Length from snout to root of tail	149^{mm}
Length of skull	35
Breadth of skull in occipital region	27
(29 allowing for fracture)	
Depth of skull in quadrate region	11

Median Plate 2	8^{mm}	transversely	by $4\frac{1}{2}$	longitudinally
" Plate 3	$5\frac{1}{2}$	"	" 2	"
" Plate 4	5	"	" $2\frac{1}{2}$	"
" Plate 5	$4\frac{1}{2}$	"	" 5	"

The succeeding plates gradually increase transversely up to 10^{mm} at about the middle of the body and then slowly diminish again. All are drawn to scale in figure 2, Pl. XXII.

The vertebral centra in front of the pelvis are $3\frac{1}{2}^{mm}$ long by 3^{mm} wide. Caudal vertebræ 3^{mm} long by 2^{mm} wide. The transverse process of the last vertebræ are 6^{mm} long.

EXPLANATION OF PLATE XXII.

FIGURE 1.—*Stegomus Longipes*, photograph natural size.
FIGURE 2.—*Stegomus Longipes*, outline drawing to show details, dotted lines indicating the portions reconstructed.
FIGURE 3.—*Stegomus Longipes*, side view of skull reconstructed.

Amherst College, Mar. 1, 1904.

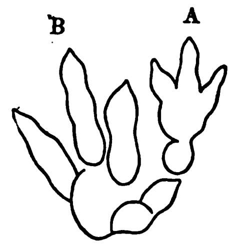
* Newton E. T. 1894. Phil. Trans., vol. clxxxv, Reptiles of Elgin Sandstones.

ᴀʀᴛ. XXXV.—*Note on the probable Footprints of Stegomus Longipes;* by R. S. Lᴜʟʟ.

Tʜᴇ discovery of a nearly complete specimen of Stegomus ı the Triassic sandstones of the Connecticut Valley proves a reat boon to the student of footprints, for it at once affords a lue to the interpretation of a most remarkable series of quadnpedal tracks which are included under the ichnite genus ʒatrachopus (Anisopus) of Hitchcock.

Briefly characterized, these tracks were made by a series of orms truly quadrupedal in gait, with a tetradactyl pes and a entedactyl manus, the latter being considerably smaller and arely showing the impression of all of the digits; sometimes our, generally but three leaving their imprints. The phalaneal pads are generally distinct and betray a formula which at nce places the group among the diaptosaurian reptiles, while he acuminate claws seem to imply a carnivorous mode of life.

In one feature this genus separates itself harply from most Reptilia, and that is in he extremely long stride in proportion to he length of the pes, the ratio of foot to tep being on the average as one to six; his together with a very narrow trackway, hown by the footprints being nearly in a ight line, would indicate a creature with ɔng stilted limbs and a gait like that of cursorial mammal. Edward Hitchcock [chnology of Massachusetts, Boston, 1858, p. 62, 63) recognized the saurian nature f the group, but could not reconcile the imb proportions with those of any known eptile, hence he reasoned that they might have been mammiferus. The inequality of the fore and hind feet together with the emote age of the impressions suggested to him the marsupials, nd he says finally that: "although the marsupial type must ave predominated the . . . . crocodilian characters . . . . ught not to be overlooked, and therefore I call the animal a *Coricoid Marsupialoid.*"



Footprints of *Batrachopus gracilis* E. Hitchcock, Natural size. A manus, B pes.

Lull, in his recent memoir (Mem. Boston Soc. Nat. Hist, vol. , No. 11, p. 482), thought that Batrachopus might represent a urvivor of the ancient dinosaurian stem from the very dinoauroid pes, which, though tetradactyl, with all of the digits ointing forward, is of such a character that the typical dinoaurian foot could readily have been derived from it The longimbed Kadaliosaurus strongly suggested the genus under con-

sideration, which was therefore provisionally placed in the order Protorosauria of Seeley. A comparison was made however between Batrachopus and Aëtiosaurus, but those forms described by Fraas lacked the proportions necessary to correlate the two genera.

In the Aëtiosaur (*Stegomus longipes*), described by Emerson and Loomis on p. 377 of this number, we find a form whose stilted limbs and comparatively narrow body give it just the proportions one would suppose Batrachopus to have, and a careful comparison with the wealth of material contained in the Hitchcock ichnological cabinet of Amherst College seems to correlate it beyond doubt with the species *Batrachopus gracilis* E. Hitchcock, for the correspondence in size is exact.

The genus Batrachopus contains three typical species, *B. deweyanus* E. H., the type species, *B. dispar* Lull, and *B. gracilis* E. H. the last presenting at least two varieties differing from each other mainly in size, each being in this respect comparatively constant, though gradational specimens do occur. Of these varieties the type specimen, the one here figured, that described by Hitchcock,* is of the smaller phase, and it is with this that *Stegomus longipes* agrees, while the larger form is that described and figured in the author's memoir (loc. cit., p. 484, fig. 3). These two forms are mainly from two localities: the typical variety being seen most commonly on a ripple-marked gray shale from the Horse Race near Gill, Massachusetts, the slabs being covered with tracks running in every direction as though the creatures were gregarious in habits, as the specimen of Aëtiosaurus described by Fraas† would also seem to indicate.

The larger variety has its typical locality at the Lily Pond quarry at Turners Falls, Massachusetts, which has yielded so many of Hitchcock's types, and the specimens are for the most part beautifully preserved impressions on a dark red shale, which preserves detail with wonderful fidelity.

Geographically *Batrachopus gracilis* ranges from Massachusetts through Connecticut, New Jersey and Pennsylvania, and hence it is sufficiently numerous and widespread to be among the species most likely to be preserved as fossils.

If one may judge from relative size, it is possible that the footprints of *Stegomus arcuatus* Marsh‡ are those to which the name *Bratrachopus dispar* Lull has been given.

It would seem therefore that the correct placing of Batrachopus would be not among the Protorosauria but in the sub-order Aëtiosauria of the order Parasuchia of Huxley.

* Mem. Amer. Acad. Arts and Sci. (2), iii, p. 228, pl. 16, fig. 3, 4.

† Württem. naturwiss. Jahres., xxxiii, 1877.

‡ This Journal (4), ii, p. 59, pl. i.

ART. XXXVI.—*The Canyon City Meteorite from Trinity County, California*; by HENRY A. WARD.

ON page 469 of vol. xxix (1885) of this Journal, Prof. Charles Upham Shepard called attention to a mass of meteoric iron purporting to come from Canyon City, Trinity County, California, whence it had been brought by Captain C. W. Davis of Holmes Hole, Mass., some ten years previous.

Through the kind aid of Mr. A. P. Crowell of Wood's Holl, I was able to find Captain Davis and to obtain the specimen, which the latter gentleman had had in his possession for more than a quarter of a century. Captain Davis' recollections of the finding of the mass were clear, yet with little detail. It was found in the summer of 1875 on the border of a little stream which flows into the Trinity River, and about three

Section of Canyon City Siderite, ½.

miles northeast from the town of Canyon City. It was brought to Captain Davis by John Driver, who discovered it on the surface of the ground. Captain Davis retained it entire during his stay of several years in Canyon City, and subsequently brought it with him to his Massachusetts home, where he had since kept it carefully wrapped in a napkin and had shown it to few visitors.

The form of the specimen was nearly a square, about 8½ by 7½ inches in length and breadth, and 2½ inches in average thickness. One surface was slightly convex, the other slightly concave. The whole surface was much oxidized, and the flaking off of scales of the decomposed iron had entirely obliterated any traces of "pittings" which it originally doubtless had over its surface. The general color of the whole is a dark yellowish brown. The weight before cutting was 18¾ lbs. We have cut several slices from the mass.

The etched sections show a strongly marked octahedral structure with large figures; the plates of kamacite vary much in

size, ranging generally from 1 to 2^{mm} in diameter, with an occasional broader one of from 3 to 4^{mm}, as will be seen in the cut. The bands of tænite are broad and quite prominent throughout the mass, the plessite in many places showing these bands crossing them in parallel layers (Laphamite markings). This is shown particularly well on some of the edges of the slices which have been oxidized, giving the tænite a somewhat comb-like effect from their relief above the weathered kamacite.

No schreibersite was noticed by a macroscopical examination. The largest troilite nodule found in any of the sections is not over 2^{mm} in diameter; others range from this down to a fraction of a mm. These latter were quite abundant, as many as sixteen of them being scattered over some of the slices. On the narrow end of three of the slices is a fissure, entirely crossing the slice, filled with troilite.

Some sections show that the oxidation of the surface had extended inward to the depth of 5^{mm} in some places. This readily accounts for the non-appearance of crust on the exterior surface of the mass, as well as the tendency in some portions to scale; also for the limonitic color of the whole.

The examination of this iron by Prof. Shepard, as noted in the article above referred to, was limited to two small pieces—barely an ounce in all—which were from the outer surface, and "had the appearance of pure limonite." It was thus, as he suggests, difficult to obtain either an exact analysis or exact specific gravity. This circumstance sufficiently accounts for the difference between his analysis and the one lately made by Mr. J. M. Davison of Rochester, N. Y. We give both below:

Shepard.		Davison.	
Iron	88·810	Iron	91·25
Nickel	7·278	Nickel	7·85
Cobalt	0·172	Cobalt	·17
Phosphorus	0·120	Phosphorus	·10
	96·580		99·37
Specific gravity, 7·1		Specific gravity, 7·68	

We have given the name of Canyon City to this iron. The town of that name no longer exists, but was known when Prof. Shepard wrote his paper. Mitchell's Atlas, edition of 1885, has Canyon City on the right bank of a branch of Trinity River in the center of Trinity County, lat. 40° 55′ N., lon. 123° 5′ W. It is satisfactory to be able to thus see rescued from the oblivion of uncertainty a meteorite which for more than a quarter of a century has been mistily known by name yet absent and unknown in substance.

ART. XXXVII.—*Two Microscopic-Petrographical Methods;* by FRED EUGENE WRIGHT.

1. "*The Determination of the Relative Index of Refraction of Minerals in Thin Section.*"*

THE relative index of refraction of two adjacent minerals in thin section can be determined under the microscope in three different ways. (1) By their relative relief, and also by the degree of apparent roughness of their surface (shagreened surface). (2) By the method of Becke's line,† whereby under high power a narrow bright band of light can be seen to travel back and forth, toward and away from one of the two minerals at their intersection as the microscope tube is raised and lowered: the rule then holding good that Becke's line moves toward the mineral with higher index of refraction on raising the microscope tube. This method is sensitive and extremely simple. The only objections to it are that in certain cases two such lines can be seen moving in opposite directions, whereupon it is difficult to decide as to the correct one, and that a certain amount of time is expended in changing from low power to high power. (3) By the method described below, which does not exhibit the two lines occasionally seen in the Becke's method, is equally sensitive and does not require the change from low to high power.

The method is based on principles developed by J. L. C. Schroeder van der Kolk in his recent "Tabellen zur mikroskopischen Bestimmung der Mineralien nach ihrem Brechungsindex,"‡ and is but an application of the same to minerals in thin section.

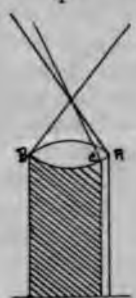
Mr. Schroeder van der Kolk determines the index of refraction of a mineral by submerging small fragments of the same in a liquid whose index of refraction can be lowered or raised by addition of other liquids until it coincides with that of the mineral, and then measuring the index of refraction of the mixture on a total reflectometer. The method is exact to the second decimal place. Mr. Schroeder van der Kolk gives in his Tabellen a list of over 300 minerals arranged according to their refractive index, and also a list of sixteen or more liquids of variable refractive index suitable to be used in connection with his method.

In actual practice, small fragments more or less lenticular in shape are taken and placed in one of the fluids. If its refrac-

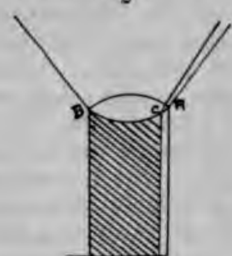
* Compare Tschermak's Miner. Petrogr. Mittheil., vol. xxi, page 238, 1901.
† Sitzungsberichte d. Kaiser. Akademie d. Wissenschaften., vol. cii, page 358–376, 1893.
‡ Wiesbaden, C. W. Kreidels Verlag, 1900.

tive index be higher than that of the liquid, it will act as a lens on the transmitted light and tend to converge the light toward the center (fig. 1); if lower than the surrounding liquid, the effect will be reversed (fig. 2). By cutting off a part of the rays (shaded parts of figs. 1 and 2) the light becomes one-sided in its effect and then exhibits characteristic phenomena. If the fragment AB (fig. 1) be observed under the microscope, the edge AC of the mineral just protruding from the darkened space BC into the light will not be reached by so many beams of light as the surrounding field, and hence will appear darker.

1



2



In fig. 2, however, the reverse is the case; the point A just outside the dark field is lighted by all the beams between A and C which are thrown together by the influence of the minerals; A will, therefore, appear brighter than the surrounding field. Moreover, as the dispersion is usually much greater for fluids than for solids, it may happen that if the refractive index for yellow rays is the same as that of the enclosing liquid, its index of refraction for red may be lower and for blue rays higher, in which case the mineral acts as a lens for the red rays and converges them toward the center (fig. 1), while the blue rays will be concentrated along the outer edge, A, which will then appear blue. When, therefore, the refractive indices of mineral and liquid are practically the same, bright colored bands appear along the edge of the mineral. Mr. Schroeder van der Kolk describes several experiments which show this phenomenon in an elegant manner. He darkens half the field by placing a small platinum plate over one half the condenser lens beneath the stage.

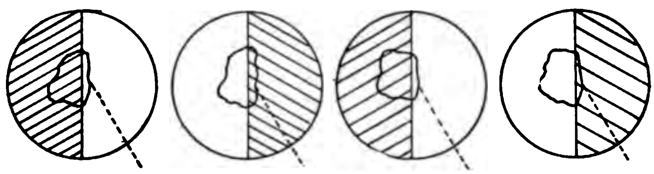
An adaption of this method, which can be effected with but slight changes, has been found serviceable in petrographic work. In the practical application of the method, the low power is used, condenser lens slightly lowered, and half the field darkened, not by means of the platinum plate mentioned above, but by placing the finger in front of the reflector below the stage and thus casting a shadow over any desired part of the field. The same effect can be produced by moving the

lower iris diaphragm found on some microscopes back and forth, or by using a stop diaphragm. The finger, however, furnishes the simplest means and after some practice is used almost unconsciously. Having thus covered half the field in shadow, observe the mineral section on the border of the shadow. If the mineral projects from the shadow into the light field, and appears still lighter and brighter, its refractive index is lower than that of the adjacent mineral. If the mineral lies within the light field and its edge protrudes slightly into the darkened half, the phenomena are reversed. The four diagrams (3, 4, 5, and 6) show the possible cases which may result.

Index of Refraction.

Lower Higher

3 4 5 6



Edge brighter darker darker brighter.

than that of adjacent mineral.

If the refractive indices of the two are about the same, the colored bands, described above, can often be seen. (Quartz and Canada balsam.)

The phenomena described above are distinct and easy recognizable. By placing the finger before the reflector and lowering the condenser lens slightly, the relative index of refraction of two adjacent minerals can be determined accurately.*

In the diagnosis of minute crystals (as chromite crystals within plates of olivine, etc.) the method has been used to advantage.

2. *On the Use of the Optic Normal in the Microscopic Determination of Minerals.*

Method for Determining the Optical Character of an Anisotropic Mineral on a Section Perpendicular to the Optic Normal. ($\mathfrak{b}$ ellipsoidal axis.)

In the thin section the only plates of an anisotropic mineral which can be recognized readily by their optical characteristics

*Mr. Geo. W. Corey of the Michigan College of Mines has recently called the attention of the writer to the fact that the relative refractive index of adjacent minerals in the thin section can be ascertained by this method without the aid of the microscope. Observe the thin section with a pocket lens, holding the slide up toward the sky; by placing the finger in front of the thin section and thus casting a shadow over part of the field, the relative index of refraction of two adjacent minerals can be determined by the rules given above; the phenomena observed are identical with those already described.

are those cut perpendicular to the three ellipsoidal axes 𝔞, 𝔟, 𝔠, and the two optic axes (optic binormals); in the uniaxial minerals these quantities reduce to plates cut parallel and perpendicular to the principal axis.

By observing the interference figures on plates perpendicular to the bisectrices 𝔞 or 𝔠 of biaxial minerals, we are able to separate the biaxial minerals from the uniaxial. The optical character of the uniaxial minerals whether positive or negative can always be determined, while in the biaxial minerals this can only be effected when the angle between the optic axes in air (2 E) is small (less than 90°)—when both optic axes appear in the field, the angle of which is 70°–90° in ordinary microscopes. For the larger part of biaxial minerals, however, 2 E is greater than 90° and cannot be used as a general factor in the practical separation of minerals by ordinary means. The same holds true for plates cut perpendicular to the optic axes. For this reason the optical character of biaxial minerals is rarely applied in their microscopic diagnosis.

By using the interference phenomena, however, observed in convergent polarized light on plates perpendicular to the optic normal (𝔟 ellipsoidal axis in the biaxial minerals, and the normal to the principal axis in the uniaxial minerals), the optical character of the rock-forming minerals can be ascertained by ordinary means.

A plate perpendicular to the optic normal (either uniaxial or biaxial) exhibits a peculiar interference figure in convergent polarized light. On revolving the stage of the microscope, the field becomes dark suddenly, remains so for an instant, only to become light again on further revolution through a few degrees. In the position of darkness the ellipsoidal axes 𝔞 and 𝔟 are parallel to the plane of vibration of the nicols. No distinct cross is seen as in the interference figures of plates perpendicular to the bisectrices. The entire field appears dark, with perhaps a weak fringe of light along the outer extremities of the diagonals of the quadrants.

If the field be placed in the dark position and turned slightly, faint, dark hyperbolas can be seen to open and leave the center of the field, similar to the dark hyperbolas of the biaxial interference figures perpendicular to the bisectrices, the chief difference between the two being one of intensity and rapidity of motion. The hyberbolas are very weak and require close observation to be noticed at all. A mineral plate of low birefraction will show them less distinctly than one of high.

Rule.—The dark hyperbolas leave the field in the direction of the acute bisectrix in the biaxial minerals and in the direction of the principal axis in the uniaxial minerals.

Application.—Observe direction in which the faint hyper-

bolas of the interference figure of an optic normal in convergent polarized light leave the field on a slight revolution from position of darkness. Determine value of this ellipsoidal axis (whether $\mathfrak{a}$ or $\mathfrak{c}$) by means of quartz wedge in parallel polarized light and with it the optical character of the mineral; on the same section the birefringence $(\gamma - \alpha)$ can also be ascertained; and in monoclinic and triclinic crystals an angle of extinction in general be measured.

Proof.—In uniaxial minerals, the rays travelling parallel to the principal axis suffer no double refraction. The height of the birefringence increases with the angle which the incident ray makes with the principal axis. On observing a section cut parallel to the principal axis in convergent polarized light, the center of the field will become bright for only a slight turn of the stage from the position of darkness, while those rays nearer the principal axis will become less bright for the same angle of revolution. Hence, on rotating the stage from position of darkness of mineral plate to light, the dark weak hyperbolas (less brightly lighted portion) appear to move out in the direction of the least double refraction, i. e. direction of the principal axis.

In the biaxial minerals the acute bisectrix is, in general, direction of lower birefringence than the obtuse. The faint hyperbolas observed in convergent polarized light on a plate parallel to the bisectrices (perpendicular to the $\mathfrak{b}$ ellipsoidal axis) will, therefore, leave the field in the direction of the acute bisectrix.

The statement that the acute bisectrix in biaxial minerals is direction of less double refraction than the obtuse bisectrix can be proved by elementary means as follows:

Let V be the angle which one optic binormal (optic axis) makes with the least ellipsoidal axis $\mathfrak{c}$ and α, β, γ, the three indices of refraction.

The equation

$$\cos^2 V = \frac{\frac{1}{\beta^2} - \frac{1}{\gamma^2}}{\frac{1}{\alpha^2} - \frac{1}{\gamma^2}} \text{*} \qquad (1)$$

which express the relation between the angle V and the indices of refraction, reduces, for $V = 45°$, to the form

$$\cos^2 V = \tfrac{1}{2}, \text{ or}$$

$$\frac{\frac{1}{\beta^2} - \frac{1}{\gamma^2}}{\frac{1}{\alpha^2} - \frac{1}{\gamma^2}} = \tfrac{1}{2}$$

*Rosenbusch-Iddings, "Microscopical Physiography of Rock-forming Minerals," 1908, p. 88.

If c be acute bisectrix, then

$$V < 45°$$

$$\cos^2 V > \tfrac{1}{2}, \text{ and, therefore,}$$

$$\frac{\frac{1}{\beta^2} - \frac{1}{\gamma^2}}{\frac{1}{\alpha^2} - \frac{1}{\gamma^2}} > \tfrac{1}{2} \qquad (2)$$

Let

$$\beta - \alpha = C$$
$$\gamma - \beta = A, \text{ or}$$
$$\alpha = \beta - C$$
$$\gamma = \beta + A$$
$$\gamma - \alpha = C + A$$

The expression (2) may now be written

$$2(\beta - C)^2 A(2\beta + A) > \beta^2(C + A)(2\beta + A - C). \qquad (3)$$

On rearranging the quantities of (3), we obtain

$$2\beta(A - C)(\beta^2 - 2CA) + \beta^2(C - A)^2 + 2C^2A^2 - 6\beta^2CA > 0 \qquad (4)$$

To prove that in the case of c acute bisectrix

$$\beta - \alpha < \gamma - \beta$$
$$C < A$$
$$A - C > 0.$$

The value of the expression (4) is evidently dependent on the value of $A - C$, for both A and C are such small quantities (fractions compared to β) that the members of (4) $\beta^2(C-A)^2 + 2C^2A^2 - 4\beta CA$ and usually $6\beta^2 CA$ may be neglected in comparison with $2\beta^3(A-C)$. The value of the expression whether greater or less than zero, depends, therefore, generally on the sign of $A - C$ as $2\beta^3$ is always +. Thus when c is acute bisectrix, in general

$$A - C > 0, \text{ or } \beta - \alpha < \gamma - \beta.$$

Hence, the acute bisectrix is, in general, direction of least birefraction. An examination of the list of all biaxial rock-forming minerals confirmed this statement.

Application.—In measuring the extinction angle in any monoclinic mineral in which $\mathfrak{b} = b$, the optical character of the mineral can also be determined at the same time by the above method. The birefringence $(\gamma - \alpha)$ can likewise be ascertained on the same plate if its thickness be known. The plate cut perpendicular to the optic normal exhibits the strongest double refraction (highest, brightest interference colors), and can be picked out readily from a number of plates of the same mineral cut along various planes. Thus a plate of monoclinic

amphibole or pyroxene ($\mathfrak{b}=b$) parallel to the clinopinacoid 010, on which the extinction angle must be measured, is also suitable to reveal the optical character of the mineral and the double refraction ($\gamma-\alpha$).

Determination of the plagioclase feldspars:

Cleavage faces parallel to the basal pinacoid 001 of the soda-lime feldspars (acid plagioclase), albite to basic andesine, show the optic normal more or less distinctly, and can be determined by the above method as such without further trouble. With this aid in the diagnosis, the separation of the acid plagioclases by the cleavage method on plates parallel to the base (striæ after the albite law) is rendered more certain, as the ambiguity of the sign of extinction is largely eliminated. (The feldspars $Ab_1An_0-Ab_8An_1$ are positive; $Ab_8An_1 - Ab_{22}An_{10}$, negative; $Ab_{22}An_{10}-Ab_1An_4$, positive; $Ab_1An_4-Ab_0An_1$, negative.)

In his "Etude sur la Determination des Feldspaths," Michel Levy has plotted a curve illustrating the extinction angles on plagioclase feldspars cut perpendicular to the optic normal ($\mathfrak{b}, n_m$). Unfortunately, the values are so nearly equal in the acid plagioclases that an exact separation of the same is not possible by this method alone. The ambiguity, however, arising from the plus or minus character of the angle between albite and oligoclase and andesine can, in general, be eliminated by the method described above. In the determination of the plagioclase feldspar by the method of Michel Levy in conjunction with the above, a plate cut perpendicular to the optic normal (highest interference color) is first selected, its angle of extinction (angle between the least ellipsoidal axis and the twinning lamellae) measured, the direction of the acute bisectrix noted and its relative value, whether $\mathfrak{a}$ or $\mathfrak{c}$, ascertained by means of the quartz wedge. By combining the extinction angle of any plagioclase with its optical character, the feldspar can in general be determined accurately.

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ART. XXXVIII.—*On the Denucleating Effect of Rotation in case of Air Stored over Water;* by C. BARUS and A. E. WATSON.

1. THE following interesting result was obtained incidentally, in connection with other researches.

If air containing nuclei from any source whatever is introduced into a cylindrical condensation chamber over pure water, and if the cylinder is rotated on its axis more or less rapidly, without further interference with the air contained, the charge of moist air will soon be found to be free from nuclei.

2. The following are examples of the results obtained. Nuclei were produced in dust-free air by passing the X-rays through a cask of paraffined wood, in the direction of an equatorial diameter, for three to five minutes. The cask was 35^{cm} in diameter and 40^{cm} long, mounted axially on an axle and turned by a small electromotor. The coronas were viewed through two longitudinal and diametrically opposite strips of plate glass. Details of construction cannot be considered here; we need merely state that the apparatus during rotation was absolutely free from leakages of nuclei, either of efflux or of influx.

The size of the corona due to nuclei generated by the X-rays is unfortunately very variable, depending (caet. par.) on conditions of radiation beyond the observer's control. Diameters ranging on an arbitrary scale from 6 to 12^{cm} were obtained for the case of rather weak radiation, passing for three to five minutes through the wood of the stationary cask. As a rule, the nuclei vanish in less than three minutes of moderately fast rotation (two turns per second), and the corona obtained thereafter is almost too weak for detection. At these speeds the whole of the water does not yet adhere as a smooth cylindrical apparently rigid sheet to the sides of the cask, but is carried around with more or less turbulent motion.

TABLE I.—Number of nuclei, n, per cub. cm. before and after rotation. Pressure difference about 22^{cm}. Nuclei produced by X-rays to the average number of 30,000 to 70,000 per cub. cm.

Experiment No.	Time of radiation. min.	Time of rotation. min.	Turns per min.	Arbitrary diameter of corona. cm.	n nuclei per cub. cm.
1	3	0	0	4·1	27000
	—	2	140	1·8	2500
	—	4	140	·0	0
2	4	0	0	5·6	69000
	—	6	120	1·1	500
3	3	0	0	1·8	2300
	—	3	64	·0	0
4	3	0	0	2·1	3600
	—	3	230	·5	50

Two reasons may be suggested for the cleansing effect of rotation: It is supposable that eddy currents are produced by the rotation, as a result of which all parts of the confined air are in succession washed on the surrounding surface of water. Such currents, however, could hardly persist but for a short time after the beginning of the rotation. In the second place, if there is churning of the pure water connected with the rotation, the enclosed air must pass in small bubbles through the water many times. This seems to be the more potent cause for the absorption of nuclei. The details of the experiments with X-ray nuclei did not conform very closely with either of these hypotheses, and we therefore decided to investigate the question thoroughly with a larger type of coronas and in a large glass vessel, through which the whole behavior could be better seen.

3. The following results were obtained with a glass cylinder about 35^{cm} long and 25^{cm} in diameter (part of an old electrical machine). It was nicely mounted axially and capable of very rapid rotation, enabling the observer to catch up the whole of

TABLE II.—Air nuclei removed by rotation. $\delta p = 17^{cm}$. Goniometer and lamp 85^{cm} and 250^{cm}, resp. from chamber.

Remarks.	Time of successive rotations. min.	Turns per minute.	s cm.	n nuclei per cub. cm.
Water in a *smooth*	0	? 450	10	(200,000)
cylindrical shell ;	3		6·4	85,000
fixed to glass walls.	3		6·1	74,000
	4		5·6	57,000
Water in very turbulent motion.	0	350	7·6	140,000
	3		3·3	12,000
	3		2·1	3,000
	3		1·2	500
Water in turbulent	0	150	8·8	(160,000)
motion.	3		5·6	57,000
	3		5·4	51,000
	3		4·2	24,000
	3		3·3	13,000
	3		2·8	7,000
	3		2·1	3,000
Time loss of nuclei	0	0	8·7	(160,000)
without rotation.	3		6·8	100,000
Slight subsidence of	3		6·2	77,000
the successive fogs.	3		6·2	77,000

***Note:* Corrections for periodicity were not applied as it did not seem necessary. The results are thus somewhat irregular. The numbers in parenthesis are estimated.**

the enclosed pure water centrifugally, or but a part of it, at pleasure. The difference of the rotational resistances for the two cases is noteworthy.

The angular diameter, θ, of the coronas was determined with a goniometer having a radius $R = 30^{cm}$ long, so that if s is the chord corresponding to R, $\tan \theta/2 = s/2R$. Goniometer and source of light were 85 and 250^{cm}, respectively, from the cylinder, and the exhaustions all corresponded to the pressure difference of about $\delta p = 17^{cm}$, at about $20°$.

The results are definite. The first and last parts of Table II show that the time loss of nuclei when the cylinder is rotating so rapidly that the water is held up as a *smooth sheet* against its sides, is not much larger than when the cylinder is stationary, in spite of the fact that in the first case some nuclei must be lost in the turbulent motion on starting and stopping. The law of decrease is as usual apparently geometric.

When the critical speed at which water is caught up on the sides is not attained, in other words, when only a part of the water contained is carried around by rotation, then the cleansing effect is very marked as the middle parts of the table show. Furthermore, nuclei are lost more rapidly per minute as the speed of rotation producing turbulent motion is greater.

Thus it follows that the nuclei are lost by the continued bubbling of the air enclosed within the cylinder through the water contained. This rotational method of making the air dust-free is frequently very convenient, particularly in those cases where slow rotation of the condensation chamber is necessary to keep the air within saturated, and in other cases to be treated elsewhere.

In conclusion, we may observe that if the continuous passage of air in bubbles through water produces ions (as has been shown by J. J. Thomson, Himstedt and others), these ions are not in evidence in the role of condensation nuclei; for the effect of churning pure water, far from being a means of generating nuclei, has in the above experiments been shown to be a very effective method of making the air dust-free. From this point of view we regard the experiments as noteworthy.

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SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *The Blue Color of Basic Lanthanum Acetate and Iodine.*—The very remarkable reaction, similar to that of starch, which basic lanthanum acetate gives with free iodine was observed by Damour in 1857, and has been frequently applied for the qualitative detection of the rare earth. The reaction has been studied recently by W. Biltz, who finds that it does not take place when the nitrate is used, and that it is dependent to a large degree upon the physical condition of the precipitate, which should possess the semi-transparent appearance of a colloidal substance. A product that is more pulverulent and white, such as is usually obtained from boiling acetate solutions, gives only a brown color with iodine. After the blue product is once formed, however, the liquid in which it is suspended may be heated to a higher temperature without injury to the color. An addition of indifferent electrolytes, such as potassium nitrate, is also without injurious action, so that the reaction may be obtained from solutions of lanthanum nitrate which have been acidified with acetic acid before precipitation. The reaction always appears with certainty when a solution of iodine in potassium iodide is added to a lanthanum acetate solution, and then enough ammonia is added cautiously, so that the brownish yellow color of iodine does not quite disappear, and finally the liquid is heated very gently. A dark blue precipitate gradually forms, or, if the solution is very dilute, a blue colored liquid is obtained. Quantitative experiments showed that the amount of iodine taken up by the precipitate is very nearly proportional to total amount present in the liquid; hence the conclusion is reached that the phenomenon, like the formation of iodized starch, is one of adsorption, and that the blue substance is not a definite compound.—*Berichte*, xxxvii, 719. H. L. W.

2. *Yellow Antimony.*—It has been known for many years that an unstable, yellow form of arsenic exists, which is analogous to yellow phosphorus. Stock and Guttmann have now succeeded in preparing a yellow modification of antimony by the action of air or oxygen upon liquid hydrogen antimonide at $-90°$. The substance is spontaneously transformed into the black form even more readily than yellow arsenic; for the change takes place in a few seconds even at $-50°$, and even at the temperature of its formation, $-90°$, it is so unstable as to become brownish or blackish in a few hours. The oxidation of hydrogen antimonide at the low temperature used for the preparation of the substance is very slow, so that the yield is small. It was shown that the yellow substance does not contain hydrogen, and that it is soluble in carbon bisulphide at a temperature somewhat higher than $-90°$, giving a strong yellow color to the solution. Imme-

diately after this solution takes place, separation of black antimony begins.—*Berichte*, xxxvii, 898. H. L. W.

3. *Action of Carbon upon Lime at the Temperature of Fusing Platinum.*—MOISSAN has heated a mixture of sugar-charcoal and quick-lime in the proportions for the formation of CaC_2, in a tube made of fused quartz, by means of an oxygen and illuminating gas blowpipe flame, to the temperature at which platinum fuses, and has found that at this temperature not a trace of calcium carbide is formed. In this connection the observation was made that silica possesses, even below its point of fusion, an appreciable vapor tension, for at 1200° there were slowly formed upon the lime small needles of an insoluble calcium silicate, a circumstance which prevents the frequent use of a tube of this kind. It was observed also that crystals of calcium carbide were not changed at the fusing-point of platinum, while platinum wire melted at once in solidifying calcium carbide.—*Comptes Rendus*, cxxxviii, 243. H. L. W.

4. *Two Sodium-Ferric Sulphates.* — SKRABAL has prepared two double salts, one basic and the other normal in composition, which are interesting from the fact that they correspond to known minerals.

The compound $FeSO_4OH \cdot Na_2SO_4 \cdot 3H_2O$, which agrees in composition with the mineral sideronatrite, is a pale yellow precipitate formed by heating a solution of 50 g. of ferric sulphate acidified with 10^{cc} of dilute (1:6) sulphuric acid and 300 g. of Glauber's salt. The other compound, $Fe_2(SO_4)_3 \cdot 3Na_2SO_4 \cdot 6H_2O$, which corresponds to the mineral ferronatrite, was prepared from a very concentrated solution of 10 g. of ferric sulphate, 100 g. of Glauber's salt and 15^{cc} of concentrated sulphuric acid. This compound is a colorless precipitate.—*Zeitschr. anorgan. Chem.*, xxxviii, 319. H. L. W.

5. *Grundlinien der Anorganischen Chemie*, von WILHELM OSTWALD. Zweite, verbesserte Auflage. 8vo, pp. 808. Leipzig, 1904 (Engelmann).—The first edition of this text-book of elementary inorganic chemistry appeared in 1900. The prompt appearance of this new edition is due in some measure to the fact that 4000 copies of the first edition were sold within three years, and no further comment is needed to show the approval of the chemical public, in Germany at least, in regard to the treatment of elementary chemistry from the standpoint of modern physical chemistry.

No very marked changes have been made in the new edition—the increase in volume amounts to thirteen pages. The author continues to maintain his curious opposition to the atomic and molecular hypotheses, although in this edition he calls molecular weights "molar-weights" in place of the still more ambiguous "normal-weights" of the other edition. It seems entirely inconsistent that he should believe so implicitly in ions but not in atoms and molecules.

Some of the numerous errors of the original book have now

disappeared, but there is no difficulty in finding them here. For instance, the reaction of hydrogen sulphide upon heated copper is given as $H_2S + Cu = CuS + H_2$, whereas it is very well known that Cu_2S would be formed; it is stated that lead tetra-acetate is a yellow salt, instead of a colorless one; and there are several errors in connection with metallurgical topics. H. L. W.

6. *A Manual of Qualitative Chemical Analysis;* by J. F. McGregory. 8vo, pp. xiv, 133. Boston, 1903 (Ginn & Company).—This text-book has been prepared to meet the wants of the author's own classes, as has usually been the case with the great number of books on this subject that have already appeared. Their number shows the existence of much diversity of opinion in regard to the best methods of teaching this branch of chemistry. The book under consideration gives a rather extensive course in the reactions of the radicals, and it seems that all of these are expected to be mastered before their analytical application is taken up. The learning of all these details without applying the knowledge and thus connecting it with analytical processes, is an exceedingly difficult matter, and it appears to the reviewer that this feature is objectionable. The attempt to avoid purely mechanical work on the part of the student by omitting tabular outlines of methods is praiseworthy. The following sweeping statement in the introduction leaves no place for the elements themselves, nor for the many "simple" inorganic substances which are neither acids, bases, nor salts: "Every simple inorganic substance consists of two parts. The first, which is a metal or positive radical, is chemically combined with the second, which is a non-metal or negative radical." The book is marred by the so-called reformed chemical spelling, which leads to incorrect pronunciation and is not in harmony with the rest of the English language as it is now written. H. L. W.

7. *Influence of Temperature and Pressure on the Absorption and Diffusion of Hydrogen by Palladium.*—The following conclusions have been reached by G. N. St. Schmidt: The absorption of hydrogen by palladium follows the phenomena of most absorbing substances above 140° C. That is, it increases with the pressure and diminishes with the temperature. The diffusion increases with the temperature and with the pressure.

This is not true under 140° C. Here enters an irregularity. We are accustomed to consider that in the course of diffusion of a gas through a solid body that first adsorption takes place, then absorption, then diffusion. Diffusion then can only take place if the gas is in the first place adsorbed by the solid body; and this happens only when a certain affinity exists. We must, therefore, assume that under 140° C. no affinity exists between hydrogen and palladium. This enters first at higher temperatures and with it adsorption. There are analogies in chemistry: for instance, carbon and nitrogen do not combine at ordinary temperatures; but at high temperature form CN.

Winkelman has found (Ann. d. Phys., 6, p. 104, 1901; 8, p. 338, 1902) that the amount of diffusion of hydrogen through palladium and platinum is not proportional to the pressure but is relatively greater with diminishing pressure. He explains this by the theory that the diffusion enters with a dissociation of hydrogen molecules and that only the hydrogen atom diffuses. This narrows the working pressure. The forcing pressure is dependent upon the difference of the adsorption on both sides of the body. The diffusing quantity is proportional to this difference. Since it is not shown that this difference is strictly proportional to the pressure, and observations prove that it more or less diminishes with the latter, it necessarily follows that the diffusing quantity is not narrowly proportional to the pressure. The theory that the forcing pressure changes through dissociation of the hydrogen molecule does not appear to be an explanation of the observed irregularity.—*Ann. d. Phys.*, 4, 1904, pp. 747–769.

J. T.

8. *Study of the Radio-activity of Certain Minerals and Mineral Waters.*—In a paper on this subject delivered by the Hon. R. J. Strutt before the Royal Society, there is the following interesting estimate of the quantity of radium in Bath water:

"According to the estimate of Sir A. C. Ramsay, the late Director of the Geological Survey, the salt annually delivered by the Bath spring would be equivalent in volume to a column 9 feet in diameter and 140 feet high. Taking the density to be twice that of water, this would weigh about 500,000 kilograms. The saline residue gives about one-fifteenth the part of the quantity of emanation that samarskite gives. Let us assume that the latter contains one-millionth part of radium, which I think is an outside estimate. At that rate the annual delivery of radium by the spring amounts to about one-third of a gram. The volume of gas which the spring delivered is about one hundred cubic feet per day (Williamson, Brit. Assoc. Reports, 1865, p. 380).

About one-thousandth part of this is helium, so that about three liters of helium are given off daily, or about one thousand liters per annum. The proportion of helium to radium thus indicated is of the same order as in radio-active minerals, though somewhat larger. This is in accordance with the view that the spring draws its supplies from the disintegration of such minerals."—*Nature*, March 27, 1904. J. T.

9. *Atmospheric Radio-activity in High Latitudes.* — A series of determinations of the radio-activity of the atmosphere have been made by G. C. Simpson at Karasjoh, Norway, in 69° 20′ N. lat. It was found that the radio-activity was very much greater than in lower latitudes; the mean for the month being 102, or about six times as great as the German mean for the year (Elster and Geitel at Wolfenbüttel), while the highest value was 432 or nearly seven times the German maximum. As regards the connection with time of day, the maximum was found to fall in the evening, the means for morning and afternoon being

nearly the same. No direct relation was found between the radio-activity and the potential-gradient; temperature and barometric pressure also seemed to have no great influence. The presence of clouds had a marked effect, however, the maximum of 432, for a clear sky, falling to 198, when the sky was completely overcast. Sudden changes were occasionally noted, as from the low value 66 to the high 384 within a few hours. The observations were made in winter when the sun was below the horizon and the surface of the frozen earth was covered with more than two feet of snow.—*Proc. Roy. Soc.*, lxxiii, 209.

10. *The Optical Properties of Vitreous Silica.*—The remarkable properties of vitrified quartz which make it suitable for certain applications in optical work are remarked by GIFFORD and SHENSTONE. It has a definite constant composition, unlike glass; is hardly attacked by any corrosive fumes (except F and HF) and is indifferent to solvents. It is also as transparent to ultraviolet radiation as quartz while it has not its double refraction. Its dispersive power is sensibly greater than that of quartz, while the refractive index is low, approaching that of fluorite. A 60° prism, 41^{mm} high by 32^{mm} wide, was made with great care from many hundreds of fine rods of vitreous silica. Another compound prism, $56^{mm} \times 38^{mm}$, was made of four distinct slabs of silica from separate meltings; when finished its performance could not be distinguished from the single prism. Values of the refractive indices for the latter prism are given for a series of wave-lengths from 7950 to 1852·2; for D (Na) the value obtained was 1·4584772. For a thin doublet of fluorite achromatized by vitreous silica it was found that the focal length was almost independent of wave-length.—*Proc. Roy. Soc.*, lxxiii, 201.

11. *Terrestrial Magnetism.*—A Department of International Research in Terrestrial Magnetism has been established by the Trustees of the Carnegie Institution. An appropriation of $20,000 was made for the organization of the work and an annual grant of like amount is expected for carrying it on. Dr. L. A. Bauer, who now has charge of the magnetic work of the Coast and Geodetic Survey, has been appointed Director of the new Department.

II. GEOLOGY AND NATURAL HISTORY.

1. *United States Geological Survey.*—The following publications have recently been issued:

TWENTY-FOURTH ANNUAL REPORT, 1902–1903; by C. D. WALCOTT, Director. 230 pp., 26 pls.—The amount of work under direction of the Geological Survey may be judged from the size of the appropriation, which last year amounted to $1,377,470. For purely geologic work there was allotted $163,700. A section of Petrology has been created, with Mr. Whitman Cross as geologist in charge. The principles of classification and nomenclature adopted in 1889 have been revised and a new code of

regulations for the making of the Geologic Atlas has been promulgated (pp. 21–28). A special appropriation of $60,000 made it possible to send five field parties into Alaska and the expansion of the work led the Secretary of the Interior to create a Division of Alaskan Mineral Resources in charge of Mr. A. H. Brooks. The section of Physics is conducting experiments upon the behavior of rock-forming minerals and upon the force exerted by growing crystals. Plans have been completed by Dr. A. L. Day and equipment provided for enlarging the scope of this work. The hydrographic work of the United States has reached enormous proportions since the law regarding the reclamation of arid lands was passed. Four divisions now constitute the hydrographic branch—hydrography, hydrology, hydro-economics and reclamation service; and the funds available for this work and not included in the appropriation for the Geological Survey amount to over $3,000,000 annually. The Survey has more than ever the confidence of the scientific and business world.

MONOGRAPH No. XLVI. The Menominee Iron-Bearing District of Michigan; by WILLIAM SHIRLEY BAYLEY. 513 pp., 43 pls., 54 figs.—This is the sixth and the last of the series of monographs to be published, dealing with the separate iron-bearing districts of the Lake Superior region. Another volume devoted to the general geology of the Lake Superior region as a whole is to follow.

The Menominee district forms a narrow tongue with an area of 112 square miles on the Michigan side of the Menominee River. It has been an important factor in the iron ore production since 1877. The district is bordered by areas of Archean schists and granites. The Huronian sediments of the district, in which occur the ore bodies, lie in a trough between these older rocks. Structurally this trough is a synclinorium composed of several important anticlines and synclines. The Huronian rocks are divided into two series called the Upper and Lower Menominee, which are separated from each other by an unconformity. The Lower Menominee series comprises 1,050 to 1,250 feet of quartzites and conglomerates with 1,000 to 1,500 feet of dolomites. The Upper Menominee series comprises the Vulcan formation, 650 feet thick and the Hanbury slate. The Vulcan formation includes three members, the iron-bearing Traders member, consisting largely of detrital ores and jaspilites, but having basal layers of slate, quartzite and conglomerate; the Brier member, composed of ferruginous and siliceous slates and the Curry member, consisting of quartzites, ferruginous quartzose slates, jaspilites and ores.

The larger ore deposits all rest upon relatively impervious foundations which are in such a position as to constitute pitching troughs. The ores of this district, like those of the Gogebic and Marquette districts, were concentrated by descending waters flowing in definite channels and the general processes involved were the same as those worked out by Van Hise for these other districts.

The book is well and abundantly illustrated and is accompanied by two detailed maps of the region. An introductory outline which serves to give a brief summary of the different chapters is included. W. E. F.

BULLETIN No. 208. Descriptive Geology of Nevada South of the Fortieth Parallel and Adjacent Portions of California; by JOSIAH EDWARD SPURR. 222 pp., 8 pls., 22 figs.—One of the gaps in the geologic map of the United States which has been heretofore unfilled is southern Nevada. This area has now been mapped in a preliminary way as part of the plan to publish a new general geologic map of the United States on the scale of about 40 miles to the inch. Mr. Spurr has confined himself to descriptive matter and has included in his bulletin the results of the geological explorations of Wheeler (1866), Gilbert (1871) and other workers.

No. 218. The Coal Resources of the Yukon, Alaska; by ARTHUR J. COLLIER. 67 pp., 6 pls., 3 figs.—Coal of commercial importance is found at many places along the Yukon River. It occurs in sandstones of Eocene and Upper Cretaceous age. The coal thus far mined ranges from high grade lignite to "rather low grade bituminous." The coal beds are sufficient to supply local demands but "will probably never supply coal for exportation." Fossils, many of them entirely new, were collected from fifty-three localities and have been studied by Drs. Stanton and Knowlton and Mr. Schuchert.

No. 219. The Ore Deposits of Tonopah, Nevada; by J. E. SPURR. 28 pp., 1 pl., 4 figs.—A detailed final report of the interesting Tonopah region from which $4,000,000 were taken the first season will be issued later, and the present bulletin gives only general outlines. The rocks in the immediate vicinity of Tonopah are Tertiary andesite, dacite, rhyolite and basalt with accompanying tuffs. The veins occur in the earliest andesite, and after a period of erosion were capped by later lavas. "The veins were formed by ascending waters succeeding and connected with the early andesite intrusion." There were four periods of hot spring action accompanied by vein formation and mineralization and each of these periods was consequent upon lava intrusion. The ore is gold and silver in the proportion of about 1 : 100 and is unusually free from base metals.

No. 220. Mineral Analyses from the Laboratories of the U. S. Geological Survey, 1880 to 1903; tabulated by F. W. CLARKE, chief chemist. 114 pp.—507 analyses of minerals of over 150 distinct species have been collected from the laboratory records, and published in one bulletin for convenient reference.

No. 221. Bibliography and Index of North American Geology, Palæontology, Petrology and Mineralogy for the year 1902; by F. B. WEEKS. 200 pp.

No. 222. Catalogue and Index of the Publications of the Hayden, King, Powell and Wheeler Surveys; by L. F. SCHMECKEBIER. 208 pp.—The early surveys of the Western United States include

Geological and Geographical Survey of the Territories (Hayden) with publications extending from 1867 to 1878; Geological Exploration of the Fortieth Parallel (King), 1871–80; Geographical and Geological Surveys of the Rocky Mountain Region (Powell); Geographical Surveys West of the 100th Meridian (Wheeler). A vast amount of valuable detail is contained in the publications of these early surveys and a complete catalogue and consolidated index make it available. Investigators, students and librarians will receive this bulletin with hearty thanks.

2. *Fossil Footprints of the Jura-Trias of North America*; by RICHARD SWAN LULL, Ph.D. Memoirs of the Boston Society of Natural History, vol. v, number 11; pp. 461–557, with one plate and numerous text-figures.—The subject of the ichnology of the Connecticut River valley, so remarkably developed by Edward Hitchcock in his works of 1848, 1858 and 1865, has received few scientific contributions for the past forty years. During this period, however, the study of the dinosaurs from the west has very greatly extended the knowledge of early reptiles, so that at the present time the conditions are much more favorable than formerly for a proper interpretation of the problematical footprints. The author has made an exhaustive study of the type specimens of Hitchcock, most of them preserved in the collections at Amherst College, and the results are given in this memoir; his conclusions are here quoted in full from the closing pages.

"The creatures, the record of whose existence has remained impressed upon the ancient shales and sandstones, may be divided into two groups in accordance with their mode of progression: those of bipedal and those of quadrupedal gait. The former, it may be safely assumed, are, in all probability, dinosaurs, for aside from man, many birds, and some modern lizards, they are the only vertebrates whose gait when erect could have been a true walk or run with alternating steps, which without exception the bipedal tracks show, there being no instance of the record of a jumping form. The presence of birds in the new red sandstone has not been proven, lizards are never *habitual* bipeds, man is clearly out of the question, hence by elimination we narrow the possible origin of such tracks down to the dinosaurian forms. This conclusion is strengthened by the presence of the fossil bones of the *Anchisauridae*, a family of primitive carnivorous dinosaurs having affinities with the Megalosauria.

The most abundant of the tracks are attributable to members of that family, creatures ranging in size from about seven to fourteen feet, so truly bipedal that the manus and tail never impress. The pes is tetradactyl, but only exceptionally does the claw of the strong grasping hallux leave a mark. The claws are rather pointed and the whole foot is very bird-like. These footprints form a natural group to which the generic name of Anchisauripus is given and which corresponds to the family *Anchisauridae*.

Allied to Anchisauripus is another carnivorous form whose foot is more specialized than that of the former in the enfeeblement of the hallux and increase of weight which has rendered the foot flatter and its pads more complex. This creature, Gigandipus, reminds one strongly of the Jurassic Allosaurus, though in the latter the claws were probably more trenchant and the whole foot more efficient as a grasping organ. Gigandipus, known from but one specimen, shows a sinuous caudal trace. The dragging of the tail probably was not habitual, but occurred only when the animal was slowing down before stopping.

Another abundant genus is Grallator, characterized by very long limbs and small, compact feet without an impressing hallux and with no tail trace. The proportions of length of limbs to those of feet are the same as in the bustards and the forms which made the tracks were probably aberrant carnivores of habits somewhat similar to those of wading birds, possibly feeding upon feebler reptiles and amphibians, or on fish. In considering the probable relationship of this genus to genera known from their skeletal remains, one is reminded strongly of Ornithomimus, a Cretaceous Compsognathoid dinosaur. Grallator comprises for the most part small forms, the smallest species, *G. gracilis*, indicating a creature but two-thirds the size of Compsognathus, the smallest known dinosaur, whose dimensions may be compared with those of the domestic cat.

Among the habitually bipedal forms, those which never impress the manus, is one group to which the name Eubrontes has been given. It includes larger and heavier forms than Anchisauripus with more blunted claws, but Hitchcock included it with the latter under the name Eubrontes and the later name Brontozoum. The two genera are so different in character that the present author is constrained not only to separate them generically but ordinally as well, for the lack of a grasping hallux, the heavy, slow-moving tread, and the blunter claws are surely not carnivorous characteristics, but seem to point rather to an herbivorous habit of life. It may be that instead of being Orthopod or Predentate dinosaurs the Eubrontes represent another group of aberrant Carnivora, which like the condor (*Sarcorhamphus gryphus*), because of carrion-feeding habits, did not retain the raptorial claws of its predacious allies. The genus Eubrontes while few as to species contains some of the most impressive forms which are fairly numerous as to individuals. *Eubrontes giganteus* represents an animal of massive proportions and of about twenty feet in length, which is nearly the maximum for American Triassic dinosaurs, though much inferior in size to those of the Jurassic and Cretaceous periods. Dinosaurs beyond question herbivorous in their habits, and hence belonging to the order Orthopoda, are the occasionally quadrupedal forms which, though walking on the hind feet, placed the fore feet on the ground while sitting. This shows that on both manus and pes the claws are short and rounded and no longer subserve a

grasping function. The particular interest which attaches to this fact is that it is the first evidence we have of Orthopoda or Predentate dinosaurs in the Trias, for their skeletal remains are entirely unknown either in this country or in Europe from the rocks of that period.

Anomoepus, the most characteristic genus among the herbivorous forms, had a pentadactyl manus with rounded claws and a tetradactyl pes with somewhat longer but still blunted claws. The hallux was but half rotated and therefore ill fitted for grasping, and there was a long metatarsus, or heel, on which the creature rested. The tail sometimes dragged just before the owner came to rest, but at other times was held clear of the ground as a counterpoise to the anterior part of the body as in other genera. Anomoepus represents a group of small, lightly built creatures ranging in size from *A. minimus*, about three feet in length, to *A. crassus*, a New Jersey form, six feet long. They are among the most numerous and interesting of all of the ichnite genera with the exception of Anchisauripus.

The genus Fulicopus, which the writer has separated from the preceding group, shows a greater amount of weight borne on the hind limbs while sitting, the manus resting but lightly as with the kangaroo. The feet resemble those of Anchisauripus more than those of Anomoepus, there being less divarication or diverging of the digits, though the position of the hallux is as in the latter genus. A curious heart-shaped impression frequently occurs just behind and between the impressions of the heels, and this was attributed by Hitchcock to the end of a truncated tail, but the writer believes it to have been made by a callosity beneath the apposed extremities of the ischial bones. Hypsilophodon, of the Wealden of Europe, most nearly suggests the probable skeletal characters of the Anomoepodoid forms, and as Professor Osborn has shown, presents the most primitive characters of any known Orthopod. It is difficult to conjecture the probable habits of Anomoepus, other than that the animals were herbivorous. They probably came to the mud flats mainly for breeding purposes, as their tracks very frequently exhibit a distinct sexual dimorphism between the footprints of the two individuals.

A very striking though rare form, Otozoum, has been placed by the present writer among the Orthopoda, although the structure of its foot is unlike that of any known dinosaur. Otozoum is probably bipedal, though there is a possibility that the great pes may have obliterated the track of the much smaller manus. The foot is plantigrade, tetradactyl, with all of the digits pointing forward and with rounded pellet-like claws and a broadly expanding web or fleshy pad extending some distance beyond the ends of the digits. Its probable function was that of supporting the creature on soft mud rather than a natatorial one. The phalangeal formula of the pes is typically dinosaurian, while that of the manus, 2. 3. 3. 3. 3, is amphibian or cotylosaurian and would be absolutely unique in a dinosaur. The manus is rarely seen and is

so obscure that there is a reasonable doubt as to the correctness of its interpretation. In one instance a dragging tail is shown which is absent in all other specimens and which is evidence in favor of the belief that the animal is a biped. Otozoum has the largest track of all, measuring twenty inches in length, but the author has no conception of the appearance of the creature itself.

Among the so-called leptodactylous or narrow-toed tracks, are many made by bipedal forms which were doubtless dinosaurs, some carnivorous, and some, judging from the manus which is occasionally seen, herbivorous in habits. The subsequent slipping of the mud after the withdrawal of the foot has obliterated most of the morphological characters from the impressions. Some of the leptodactylous forms have been identified with the better known genera and species; others which cannot be so identified because of their obscurity may nevertheless be identical with known forms, while still others evidently do not occur elsewhere. It is a notable fact that while the number of genera and species which have been erected upon these impressions is large, the number of individuals represented is proportionately small, and these are mainly from one or two localities.

Of the truly quadrupedal forms the most interesting is Batrachopus, whose long limbs, tetradactyl, plantigrade pes with acuminate claws, and phalangeal formula of 2. 3. 4. 5, and whose pentadactyl manus are such as one would expect to find in the dinosaurian ancestor. It seems possible, therefore, that Batrachopus represents a persistent type whose affinities are near the dinosaur stem form and which should be classed with Kadaliosaurus in the superorder Diaptosauria of Osborn. Batrachopus may have been a true dinosaur which had retained, among other primitive characters, the ancestral quadrupedal gait. The mode of progression was a true walk like that of a mammal and not the sprawling crawl of modern reptiles. Batrachopus included small forms of carnivorous habits.

There remain other quadrupedal forms, generally of small size, whose tracks, aside from the number of digits, size of the foot, and the length of limb, afford almost no date whereon to base a theory as to their affinities. Professor Osborn has likened ichnological interpretation to the deciphering of ancient cuneiform inscriptions which are utterly unintelligible unless one possesses the key. That the key to the deciphering of the dinosauroid tracks has been found seems evident, but in the attempt at the interpretation of the obscurer quadrupedal footprints the student is still very much in the dark."

3. *The Non-metallic Minerals; their Occurrence and Uses;* by GEORGE P. MERRILL, Head Curator of Geology in the U. S. National Museum, etc. Pp. xi, 414. New York, 1904 (John Wiley & Sons).—This work has grown out of the author's Guide to the Collections in Applied Geology in the U. S. National Museum. While it does not attempt to be a complete text-book, it brings together a large amount of interesting data in regard

to the uses of the non-metallic minerals and their occurrence and mining, particularly with reference to the localities in this country. The mineralogist will find it a useful and instructive volume to accompany the usual text-books, and to the practical worker it will be an almost indispensable compendium of information not easily found elsewhere. A series of thirty-two plates are introduced in addition to text figures; many of these are devoted to views of mineral quarries.

4. *Lehrbuch der Mineralogie;* von MAX BAUER. Zweite, völlig neubearbeitete Auflage. Mit 670 figuren. Pp. xii, 924. Stuttgart, 1904 (E. Nägele).—This second edition of the well-known text-book by Professor Bauer gives evidence in its size of the progress which the science has made since the first edition was published in 1886. The volume now runs to nearly one thousand pages, of which about one-half are devoted to the physical and chemical characters of the species. The matter has been rewritten throughout from the modern standpoint and brought strictly up to date, as is particularly obvious in the chapters devoted to Crystallography. The descriptions of species are full and the general statement of characters which precedes each group adds much to the clearness of the whole discussion.

5. *Annual Bulletin of the Mineral Resources of Kansas,* 1903; by ERASMUS HAWORTH, State Geologist. Pp. 135, Lawrence, Kansas, 1903 (The University Geological Survey of Kansas).—The total production of the mining metallurgical industries of Kansas amounted to over $23,000,000 in 1902, a much larger sum than has been reached before. The most important developments of the year were in the production of coal, the yield of which was upward of 5,000,000 tons, and also of oil and gas from localities in the southeastern part of the state.

6. *A Bibliography of the Geology, Mineralogy and Paleontology of Brazil;* by JOHN C. BRANNER. Pp. 115, 4to. From vol. xii of the Archivos do Museu Nacional do Rio de Janeiro, 1903.—This is the first comprehensive bibliography of the geology of Brazil and contains 1203 titles, not including abstracts and reviews. The author remarks that the great bulk of the geological work in the country has been done by Eschwege and by Derby, the influence of the latter having been particularly important.

7. *The Willamette Meteorite;* by HENRY A. WARD. Proceedings of the Rochester Academy of Science, iv, pp. 137–148.—The Willamette meteorite was discovered near the border of Clackamas County, Oregon, in the autumn of 1902. It is remarkable for its very great size, its extreme dimensions as taken by Mr. Ward being as follows: Length, 10 ft. 3½ in.; breadth, 7 ft.; vertical height, 4 ft.; circumference of base, 25 ft. 4 in. It has a roughly conical form, with an oval base and dome-like summit. Its weight is estimated as being approximately 13½ tons. When the mass was found the cone-shaped portion was below, while the flat base was near the surface of the ground. The former, which

was obviously the front side in the progress of the meteorite though the air, shows in the first place a border area quite covered with the usual pittings; also a number of round well-defined bore-holes mostly near the lower border explained by the disappearance of cylindrical nodules of some sulphide as troilite; and, finally a series of deep open basins and broad channels of great size, which are regarded as owing their origin to the friction of the compressed air in the rapid passage of the meteorite. The base of the mass, 10 ft. × 7 ft. in dimensions, is also remarkable in another way, since the once continuous surface is now largely replaced by a labyrinth of basin-like cavities, some of them very large. These are believed to have been formed by the decomposition of the mass under the action of terrestrial agencies, chiefly water, as it lay for an unknown period with the side exposed. An etched surface of the iron shows the usual crystalline figures and assigns the meteorite a place in the group of octahedral irons. The analysis shows that the mass contains 8 per cent of nickel. The plates accompanying the paper give striking views of the remarkable features of this extraordinary mass. The ownership is at present the subject of litigation, so that the final disposition of the specimen is yet in doubt.

8. *British Tyroglyphidæ;* by ALBERT D. MICHAEL. Volume I, 1901, pp. xiii+291; plates xix; Volume II, 1903, pp. vii+183; plates xxxix. London (The Ray Society).—Mr. Michael's ability as a student of Acarina was well demonstrated by his excellent monograph of the Oribatidae, published by the Ray Society in the 40th year of the Society (1883) and the 44th year (1887). His work upon the Tyroglyphidæ has, therefore, naturally attracted much attention from systematic workers in Arachnology. The first volume contains a full history of literature, an account of the classification, an extended description of the external and internal anatomy, and a chapter on the development of the immature stages. These chapters are followed by Part II, which contains systematic descriptions of the genera and species through the important and remarkable genus Glycyphagus. The second volume, beginning with the genus Chortoglyphus, completes the British fauna in this important family. There is added to this a list of the species foreign to Great Britain, and a bibliography. In his review of the classification of the Acarina, Mr. Michael, I think, does an inadvertent injustice to an American author, Mr. Nathan Banks, in his criticism of Banks's classification published in 1894. In the classification of the American writer little attempt was made at novelty in the characters employed. It was based upon the previous classifications of Canestrini and Trouessart, and, with slight modifications of these systems, consisted mainly in the erection of the principal groups into superfamilies with the "oidea" termination now generally adopted by systematic zoologists as indicative of superfamily rank. The points criticised by Michael in the classification are points originated by Trouessart and Canestrini and not by Banks.

The group Tyroglyphidæ is a most interesting and important one, comprising, as it does, species which occur commonly upon flour and meal, upon cheese, upon dried vegetables and drugs, and upon various plant growths, usually moribund but occasionally probably healthy. Interesting errors have occurred in previous observations upon mites of this family, and especially the striking blunder of Cross, who believed that he had created one species in his galvanic batteries. Another error has been the description of species brought up as living in the depths of the sea, when, in reality, the dredge had picked them off the surface of the water on which they were floating. Systematists in other groups in zoology will be interested to note that Mr. Michael seems not disposed to agree to the opinion of the committee of the International Zoological Congress, that the rule abolishing names founded upon larval forms should hold with the Acarina. Economic entomologists will be especially interested in Mr. Michael's conclusion that *Tyroglyphus phylloxeræ* Riley, a species which was supposed to feed on the grape vine phylloxera and which was imported from the United States into France to destroy this great pest, is a synonym of *T. mycophagus* Mégnin, does not feed on living insects, and already existed in France. The plates are very carefully done and are very beautiful. To the reader not previously informed concerning the anatomy of the species of Glycyphagus, for example, the representation of several species of this genus may be a revelation. L. O. HOWARD.

III. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *National Academy of Sciences.*—The spring meeting of the National Academy was held at Washington, April 19 to 22.

Four new members were elected at this meeting: William Morris Davis, Harvard University; William Fogg Osgood, Harvard University; William T. Councilman, Harvard Medical School; John U. Nef, Professor of Chemistry, Chicago University.

The following foreign associates were also elected: Prof. Dr. Paul Ehrlich, Frankfurt; Prof. Dr. H. Rosenbusch, Heidelberg; Prof. Emil Fischer, Berlin; Sir William Ramsay, London; Sir William Huggins, London; Prof. Geo. H. Darwin, Cambridge; Prof. Hugo de Vries, Amsterdam; Prof. Ludwig Boltzmann, Vienna. The Draper gold medal was presented to Prof. George E. Hale of the Yerkes Observatory, for his researches in astrophysics.

The following is the list of papers presented:

E. L. NICHOLS and ERNEST MERRITT: On fluorescence spectra.

JOHN TROWBRIDGE: Spectra of gas at high temperatures.

THEODORE LYMAN: Short wave-lengths of light.

H. W. MORSE: Spectra produced by the Wehnelt interrupter.

GEORGE F. BARKER: Note on radio-activity and autoluminescence.

R. S. WOODWARD: A double suspension apparatus for determining the acceleration of gravity. The compressibility of the earth's mass required by the Laplacian law of density distribution.

HENRY L. ABBOT: The disposition of rainfall in the basin of the Chagres.
A. F. ZAHM: Surface friction of the air at speeds below 40 feet a second.
R. H. CHITTENDEN: Physiological economy in nutrition, with special reference to the minimal proteid requirement of the healthy man.
HENRY F. OSBORN: Recent paleontological discoveries by the American Museum exploring parties. Reclassification of the Reptilia.
W. D. MATTHEW: Position of the limbs in the Sauropoda.
HORATIO C. WOOD, JR.: A preliminary report upon Apocynum cannabinum.
ARTHUR T. HADLEY: Biographical memoir of James Hadley.
CHARLES L. JACKSON: Biographical memoir of Henry Barker Hill.
ALEXANDER GRAHAM BELL: The multi-nippled sheep of Beinn Bhreagh.
SIMON NEWCOMB: Application of new statistical methods to the question of the causes influencing sex.
C. S. PEIRCE: Note on the simplest possible branch of mathematics.

2. *Report of the Superintendent of the Coast and Geodetic Survey, showing the Progress of the Work from July 1, 1902 to June 30, 1903.* Pp. 1032, 4to, with numerous plates and sketch maps. Washington, 1903.—This volume contains the usual report (pp. 1–22) by the superintendent, O. H. Tittmannn, of the work accomplished by the Survey in the year ending June 30, 1903. Then follow seven Appendixes on details of field and of office operations; on precise leveling in the United States 1900–3; on triangulation southward along the ninety-eighth meridian in 1902; on magnetic observations from July 1, 1902 to June 30, 1903, etc.

3. *The 1900 Solar Eclipse Expedition of the Astrophysical Observatory of the Smithsonian Institution;* by S. P. LANGLEY, Director, aided by C. G. ABBOT. Pp. 26 with twenty-two plates. Washington, 1904.—The official report of the highly successful observations of the 1900 solar eclipse by the Smithsonian party at Wadesboro, N. C., is here presented. Of the accompanying plates the first gives a striking general view of the corona obtained from a 82-second exposure with the 11-foot focus camera; other beautiful plates give detailed illustrations of portions of the inner corona from 16-second exposure with the 135-foot focus camera, etc.

4. *Physique du Globe et Meteorologie;* par A. BERGET. Pp. 353; 128 figures and 14 colored double-page plates. Paris, 1903 (C. Naud).—This volume is the basis of an elementary course which the author is conducting at the Sorbonne, and appears at the suggestion of M. Velain. It is a serious and, on the whole, rather successful effort to collect all of the known facts that bear on meteorology. It is essentially non-mathematical; even elementary mathematical discussions being separated from the text proper by smaller type.

The book is divided into three parts, the first treating of terrestrial physics; 124 pages being devoted to the discussion of the size and position of the earth, its movements, determination of its density, universal gravitation, cosmogony, geodesy, the methods of determining g, with historical treatment, and terrestrial magnetism.

The second part deals with the physics of the ocean; its constitution, tides, the propagation of waves and currents are considered. The remainder of the book is devoted to the physics of

the atmosphere, under the topics: astronomical phenomena, constitution of atmosphere, actinometry, atmospheric pressure, winds, cyclones and anti-cyclones, centers of high pressures, periodical winds, general circulation, atmospheric perturbations, hygrometry, electrical phenomena, climate, forecasting.

The treatment is thoroughly French; still, the author acknowledges his regret that the observations in different parts of France (where they appear to differ in time by as much as four to five hours) are not made simultaneously and frequently as are those in this country. The slowness in the development of meteorology, he considers, is due rather to a lack of skill exercised in making observations than to any lack in the volume of records.

Despite the variety of subjects treated, the book is without an index. D. A. K.

5. *Ostwald's Klassiker der Exacten Wissenschaften.* Leipzig, (Wilhelm Engelmann).—The following volumes have been recently added to this important collection of reprints of classical scientific memoirs:

No 140. Experimental-Untersuchungen über Elektricität; von Michael Faraday. XX bis XXIII Reihe. Herausgegeben von A. J. von Oettingen. Pp. 174.

No. 141. Über die Bestimmung einer Elliptischen Bahn aus drei vollständigen Beobachtungen; von J. F. Encke. Über die Bestimmung der Bahn eines Himmelskörpers aus drei Beobachtungen von P. A. Hansen. Herausgegeben; von J. Bauschinger. Pp. 162.

No. 142. Fünf Abhandlungen über absolute elektrische Strom- und Widerstandsmessung, von Wilhelm Meyer und Rudolph Kohlrausch. Herausgegeben; von Friedrich Kohlrausch. Pp. 116.

6. *Studies in Heterogenesis;* by H. CHARLTON BASTIAN. Pp. ix + 354 + xxxvii, 19 pls. containing 815 reproductions from microphotographs. London, 1904 (Williams & Norgate.)—Heterogenesis as defined by Dr. Bastian is "the production from the substance of organisms or their germs of alien forms of life." Numerous instances are given to show transformation of the contents of vegetal cells to amœbæ and monads, of algæ to diatoms. The egg of the Hydatina can be transformed into a ciliated infusorian! The processes by which Dr. Bastian arrives at his startling conclusions will hardly stand the test of modern scientific research.

OBITUARY.

M. F. A. FOUQUÉ, the distinguished French geologist, petrographer and mineralogist, died at Paris on March 7, in his seventy-sixth year.

M. HENRI PERROTIN, the eminent French astronomer, Director of the Observatory at Nice, died early in March at the age of fifty-eight years.

Professor FREDRIK ADAM SMITT, the well known Swedish geologist, died on February 19, in his sixty-fifth year.

Dr. JAMES HYATT, one of the pioneers in science in this country, died at Bangall, N. Y. on February 27, in his eighty-seventh year.

C. E. Beecher.

THE

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[FOURTH SERIES.]

CHARLES EMERSON BEECHER.

ONE of America's leading paleontologists, in the fullness of intellectual power, suddenly passed away on February 14, 1904, in the midst of his family and work. Few men were better prepared and more promising of great results for the next twenty years than Charles E. Beecher. "There is no doubt that in the death of Professor Beecher, not only has Yale sustained a serious loss and paleontology a severe blow, but the ranks of those capable of bringing to the study of fossils keen insight and a philosophical spirit of enquiry, guided by principles whose value can hardly be exaggerated, are diminished by one whom science could ill afford to lose, and to whom, humanly speaking, there should have remained many years of industry and fruitful research." (W. H. Dall, Science, March 18, 1904.)

Like most successful students of organic life, Beecher was a born naturalist. As a boy of twelve years he began to make a collection of recent shells and fossils, continuing to add to this for the next thirty years, when, in 1899, he presented Yale University, "unconditionally," with upwards of 100,000 fossils. In the field few excelled Beecher as a collector. When twenty years of age he published his first paper—a list of the land and fresh-water shells of Ann Arbor, Michigan. For the next eight years he published nothing, his second paper appearing in 1884, and in 1888, when he left Albany,

there were but twelve papers to his credit. Since that time, during the years spent at New Haven, he has written fifty-eight articles, making a total of seventy numbers in his bibliography. As a paleontologist he began by describing species and genera, but later he took almost no interest in this kind of work. Often he told the writer that he wished all our fossils were named. Of faunal and stratigraphic papers he has five, and of new species he described but thirty-six. He defined nine new genera and seven new orders. During the past fifteen years his mind was absorbed in working out the ontogenetic stages in fossil species and in tracing their genetic sequence through the geological formations. To Beecher we owe the first natural classification of the Brachiopoda and Trilobita, based on the law of recapitulation and on chronogenesis. He also gave a very philosophic account as to the origin and significance of spines in plants and animals. On these works his reputation in days to come will chiefly rest.

Beecher was not only a born naturalist but also had much mechanical ability. Nothing pleased him more than to free fossils from the surrounding matrix, and his unexcelled talent in this direction is shown in the preparations of *Triarthrus* and *Trinucleus* in the Yale University museum. More than 500 specimens have been prepared by him and this work has required peculiar skill, patience, ingenuity, and a great deal of time. Few can appreciate Beecher's remarkable talent in cleaning the adhering black shale from these small specimens, and it will be a long time before another will be found who can equal him in this respect. It is very unfortunate that he did not live to complete his studies on the trilobites, but he left all the better specimens completely worked out, and of most of these he had made photographs and drawings. His mechanical bent was also evidenced at his home, where he had a bench and a large kit of tools. Here his diversion consisted in making brass scrolls, shelves, and delicately carved boxes and chests. His preparations for the microscope, also, are of the best, and much time in his earlier years was spent in freeing and mounting the lingual dentition in small species of living gastropods. He likewise modeled and made a life-size restoration of the Devonian giant *Stylonurus*.

After Beecher's appointment as Curator of the geological collections at Yale, he also undertook to arrange, develop, and place on exhibition the large Marsh collection of vertebrates. His work in this connection, however, was chiefly directive, although he assisted considerably in the mechanical work of the large mounts of *Claosaurus annectens* and *Brontosaurus*. The life-like poses selected for these specimens are evidences of his artistic perception. The former he has described at length in the Transactions of the Connecticut Academy.

Charles Emerson Beecher, son of Moses and Emily D. Beecher, was born in Dunkirk, New York, October 9, 1856. Not long after this date, his parents removed to Warren, Pennsylvania, where he prepared for college at the High School, and was graduated from the University of Michigan, receiving the degree of B.S. in 1878. The ten succeeding years he served as an assistant to Professor James Hall, and in 1888 removed to New Haven to take charge of the collections of invertebrate fossils in the Peabody Museum. His career as a teacher of geology began in 1891 when for two years he took charge of Dana's classes at Yale, and in 1892 he was made Assistant Professor of Historical Geology in the Sheffield Scientific School, serving in this capacity until 1897 when he became Professor of Historical Geology and a member of the Governing Board in the Sheffield Scientific School. In 1899 he succeeded the late Professor Marsh as Curator of the geological collections, and was made a member of, and secretary to, the Board of Trustees of the Museum. In 1902 his title was changed to that of University Professor of Paleontology. He was eminently successful as a teacher both with undergraduates and with advanced students, his enthusiasm and kindliness of character arousing at once their interest and devotion.

Professor Chittenden, director of the Sheffield Scientific School, has said of Beecher: "Quiet and unassuming he never sought adulation, but where there was earnest work to be done, requiring skill, patience and good judgment, he would labor quietly and industriously, bringing to bear upon the problem such a measure of common sense and of thoughtfulness that confidence and respect for his conclusions were inevitable.

. . . . As a friend he was loyal and trustworthy, and his memory will always be cherished by his associates in the Sheffield Scientific School with a full realization of the great loss they have sustained in his removal from their midst, and with an equal realization of the great loss to the institution to which he was so ardently devoted and in the future of which he had such great confidence."

Beecher received the degree of Ph.D. from Yale in 1889, his thesis being a memoir on the Ordovician Brachiospongidæ. In 1899 he was elected a member of the National Academy of Sciences, a foreign correspondent of the Geological Society of London, and a fellow of the Geological Society of America. In 1900 he was elected President of the Connecticut Academy of Arts and Sciences, and filled this office for two years. He was also a member of the American Association of Conchologists, Geological Society of Washington, Boston Society of Natural History, and Malacological Society of London.

Beecher's first paleontologic paper was published by the Geological Survey of Pennsylvania in 1884, when he was twenty-eight years old. It treated of new genera and species of Phyllocarida from the Devonian, a group of rare Crustacea, most of which he had found about his home. He was always on the lookout for these rare fossils, and after securing many hundred additional specimens, he again returned to the subject, and in 1902, in a paper published by the Geological Society of London, embodied all that is known of the Upper Devonian Phyllocarida of Pennsylvania.

If, during the past ten years, Beecher's time had not been so much taken up with trilobites, he probably would have worked out a phylogenetic classification of the corals. In 1891 he published two important papers on paleozoic corals, one based on *Pleurodictyum lenticulare* and the other on *Michelinia convexa*. He concluded that poriferous corals begin with a simple cyathiform corallite, without mural pores, and with septa first appearing toward the end of this stage. These features "indicate a primitive, simple, and imperforate ancestry for the Perforata." The next stage is suggestive of *Aulopora*, and the final stage in *P. lenticulare* has at least seven mural pores open-

ing into the primary calyx. In regard to the mural pores, he concluded from a study of them in *Favosites*, *Striatopora*, *Pleurodictyum*, and *Michelinia*, that they "are ineffectual attempts at budding, resulting only in the perforation of the cell walls."

In his third paper on corals he states that a specimen of *Romingeria umbellifera* measuring 100×200^{mm} has approximately 1500 corallites on each zone, or 4500 on the three zones. In 85 per cent of individuals each corallite gives rise to twelve buds, so that if each of the 1500 corallites of the basal zone give rise to twelve buds, there should be on the third zone 253,500 corallites. However, as there are only 4500 in the specimen in the three zones, "this shows a suppression of 243,000 corallites on two zones."

Beecher's first turn from stratigraphic paloentology to pure paleo-biology and correlation had its origin in the brachiopods. While at Albany he became acquainted with Hyatt's principles, although it was not until he had been some years at New Haven that he fully appreciated their application to fossils. Hall had made large collections of the Silurian fossils at Waldron, Indiana. This collection contained many slabs, and, as much loose clay adhered to them, Beecher saved the washings and out of these he and Clarke obtained about 50,000 specimens of young brachiopods. Their results were published in 1889 in a well-illustrated paper entitled "Development of some Silurian Brachiopods." In summing up the developmental changes, they made the following very significant statement: "In nearly every species the inceptive state is represented by a shell having a subcircular outline, with valves of slight convexity. This phase usually disappears before the individual reaches a length of 1^{mm}, after which the specific characters are assumed." Widely differing species "are alike in form, contour, convexity, beaks, and cardinal area, and the only marked differences are to be found in the faint indications of plications, striæ, folds and sinuses."

From a study of the nature of the pedicle opening they concluded that the "phylogenetic development tended in two main channels—one leading through *Strophomena*, *Scenidium*, *Orthisina*, *Leptæna*, *Chonetes*, *Productus*, and *Strophalosia*, and the other in the direction of *Rhynchonella*, *Spirifer*,

Atrypa, *Retzia*, and *Terebratula*." It will be noticed that this arrangement of widely differing genera foreshadows two orders of brachiopods for which Beecher later proposed Neotremata and Telotremata.

My acquaintance with Beecher began in 1889, and at that time it was evident that the paper just referred to was being considered with a better understanding of what Hyatt's principles meant when applied to Brachiopoda. The very fact that nearly all the Waldron, Indiana, brachiopods began with smooth shells having a subcircular outline, led him to look for this early stage in other genera, but as no other young shells were at hand, he resorted to a study of the beaks in well-preserved examples of mature shells. During the fall of 1890 he spent nearly a week going through my collection, and with studies made on other collections he was able to announce in the spring of 1891 that he had seen the initial shell in fifteen families as recognized by Œhlert in Fischer's "Manuel de Conchyliologie," these being represented by forty genera.

At this time he made the important announcement "that all brachiopods, so far as studied by the writer, have a common form of embryonic shell, which may be termed the *protegulum*." The protegulum is the phylembryonic stage of Brachiopoda. A prototype preserving throughout its development the main features of the protegulum was at first supposed to exist in the Lower Cambrian *Paterina*, but as this proved to be identical in structure with *Iphidea*, the conclusion had to be abandoned. However, at maturity this genus is so closely related in general form with the protegulum, that we may hope at any time to find the prototype.

A study of the stages of growth in many brachiopods, from the Cambrian to the living forms, enabled Beecher to show that the old classifications based upon the presence or absence of hinge teeth, the nature of the intestinal canal, etc., were not expressive of genetic relationship. He demonstrated that on the basis of types of pedicle openings all brachiopods are naturally grouped into four orders, of which two are without and two possess hinge teeth. The most primitive order (*Lingula*, etc.) he named Atremata, and this gave rise directly to the Telotremata (*Rhynchonella*, *Terebratula*, etc.). The Neotremata (*Crania*, *Discina*, etc.) also originated in the Atremata,

and from the former descended the Protremata (*Strophomena*, *Productus*, etc.).

One of the clearest cases of parallelism between the ontogeny and phylogeny in a group of invertebrates was described by Beecher. Living species of the family Terebratellidæ have a very wide distribution, and he showed that the highest genera of the austral forms "pass through stages corellated with the adult structure in the genera *Gwynia*, *Cistella*, *Bourchardia*, *Megerlina*, *Magas*, *Magasella*, and *Terebratella*, and reach their final development in *Magellania*." In the forms having a boreal distribution the metamorphoses corellate "with adult structures of *Gwynia*, *Cistella*, *Platidia*, *Ismenia*, *Mühlfeldtia*, *Terebratalia*, and *Dallina*. The first two stages in both subfamilies are related in the same manner to *Gwynia* and *Cistella*. The subsequent stages are different except the last two, so that the *Magellania* structure is similar in all respects to the *Dallina* structure, and *Terebratella* is like *Terebratalia*. Therefore *Magellania* and *Terebratella* are respectively the exact morphological equivalents to, or are in exact parallelism with *Dallina* and *Terebratalia*.

"In each line of progression in the Terebratellidæ, the acceleration of the period of reproduction, by the influence of environment, threw off genera which did not go through the complete series of metamorphoses, but are otherwise fully adult, and even may show reversional tendencies due to old age; so that nearly every stage passed through by the higher genera has a fixed representative in a lower genus. Moreover, the lower genera are not merely equivalent to, or in exact parallelism with, the early stages of the higher, but they express a permanent type of structure, as far as these genera are concerned, and after reaching maturity do not show a tendency to attain higher phases of development, but thicken the shell and cardinal process, absorb the deltidial plates, and exhibit all the evidences of senility."

In 1893 there was discovered in the Utica formation near Rome, New York, a thin band not more than one-fourth of an inch thick, in which nearly all the fossils preserved (*Triarthrus* and *Trinucleus*) occur as pseudomorphs in iron pyrite, and retain antennæ and legs. Specimens of trilobites with legs had been known before in two specimens, and in four genera

the legs had been determined by slicing enrolled individuals. Antennæ, however, had not been clearly made out until 1893, when their presence was announced in the August number of this Journal. This discovery was of great value and promised much toward a better understanding of the ventral anatomy of trilobites and their systematic position among the Crustacea. This led to Beecher's visiting the locality in 1893 to take out several tons of the shale. Even as late as last fall he developed from this material specimens of *Trinucleus* showing the ventral appendages in the greatest detail. Since 1893 Beecher has published fifteen papers on the trilobites. Of these three are devoted to the larval stages, seven to the ventral anatomy, and five to classification and the systematic position of these forms.

The ventral anatomy is most completely known in *Triarthrus*, "an active creature" belonging to an ancient Cambrian family. Beecher showed that in this genus the entire series of thoracic legs are biramous, one of them setæ-bearing and used for swimming (expodite), and the other without setæ and used for crawling (endopodite). The limbs of the pygidium overlap each other, are much crowded, and are adapted for swimming or guiding the animal, although they may also have served as egg carriers. The individual segments "are considerably expanded transversely, thus making a paddle-like organ." The head has five pairs of appendages as follows: Anterior antennæ or uniramous antennules attached at the side of the hypostoma, followed by four pairs of biramous appendages closely resembling the thoracic legs. These are (1) posterior antennæ, (2) mandibles, (3 and 4) maxillæ. The ventral membrane of *Triarthrus* "is of extreme tenuity" and is an "uncalcified, chitinous, flexible pellicle, and thus was in strong contrast with the much thicker and calcified dorsal test."

The larval stages he studied in nine genera ranging from the Cambrian to the Lower Devonian. He concluded that "all the facts in the ontogeny of the trilobites point to one type of larval structure." This larva, not more than one millimeter in length, is "characteristic of all trilobites, and among different genera, varying only in features of secondary importance. This stage may therefore be called the *protaspis*." He found that Barrande's four orders of trilobite development are but stages of his first order, and that *Agnostus* is "neither

the phylo-typembryo nor the phylo-phylembryo, but is really the adult equivalent to an early segmented stage of the higher genera." Beecher divided the early stages of development in trilobites as follows: "Nauplius (Cephalon predominating, other parts not separated from it), Phylembryonic (Cephalon distinct, thorax nothing, pygidium distinct), Nepionic with as many stages as there are normal thoracic segments (Cephalon distinct, thorax incomplete, pygidium distinct), Neanic (Cephalon, thorax and pygidium all distinct and complete; growth incomplete), Ephebic (all parts complete and full size attained)."

The protaspis is homologous to the crustacean nauplius, which had "potentially five cephalic segments bearing appendages, which should therefore be taken as characteristic of a protonauplius. The nauplius is a modified crustacean larva. The protaspis more nearly represents the primitive ancestral larval form for the class, and approximates the protonauplius."

The basis for Beecher's classification of the trilobites is the application, for the first time, of the law of morphogenesis, or the recapitulation theory. He observed that in the first or unsegmented stage of the most primitive trilobites there are neither dorsal free cheeks nor eyes, but that in some of the later forms both the eyes and free cheeks have migrated to the anterior margin or may even have progressed a little posteriorly down the dorsal side of the protaspis. This led him to undertake a study of all trilobite genera, more than two hundred in number, and it was seen that these could be arranged in three groups on the basis of the nature and position of the free cheeks. In the most primitive order, or the Hypoparia, there are "free cheeks forming a continuous marginal ventral plate of the cephalon, and in some forms also extending over the dorsal side at the genal angles." In the Opisthoparia the dorsal "free cheeks include the genal angles, thus cutting off more or less of the pleura of the occipital segment;" while in the Proparia, or the last order to arise, "the pleura of the occipital segment extend the full width of the base of the cephalon, embracing the genal angles."

There is much diversity of opinion regarding the rank of trilobites in a classification of the Crustacea. Beecher regarded them as a sub-class and as equal in rank to the Entomostraca and Malacostraca. "In nearly every particular the trilobite is very primitive, and closely agrees with the theoretical crusta-

cean ancestor. Its affinities are with both the other sub-classes, especially their lower orders, but its position is not intermediate."

In 1892 Beecher became greatly interested in the significance of spines, accumulating data until 1898, when he presented his studies in a paper entitled "The origin and significance of spines." This paper Beecher regarded as his best and most philosophic work. In the opening paragraph he states "the presence of spines in various plants and animals is, at times, most obvious to all mankind, and not unnaturally they have come to be regarded almost wholly in the light of defensive weapons." "Their importance lies not in what they *are*, but in what they *represent*. They *are* simply prickles, thorns, spines, or horns; they *represent*, as will be shown, a stage of evolution, a degree of differentiation in the organism, a ratio of its adaptability to the environment, a result of selective forces, and a measure of vital power."

"In tracing the ontogeny of a spinose form, it has been found that each species at the beginning was plain and simple, and at some later period, spines were gradually developed according to a definite sequence of stages. Usually after the maturity of the organism, the spines reach their greatest perfection, and in old age, there is first an over-production or extravagant differentiation followed by a decline of spinous growth, and ending in extreme senility with their total absence."

He found that all kinds of spines in plants and animals can be arranged into eleven distinct categories. Further, that two generalizations result as follows: "That spinosity represents the limit of morphological variation, and second, it indicates the decline or paracme of vitality." "Finally it is evident that, after attaining the limit of spine differentiation, spinose organisms leave no descendants, and also that out of spinose types no new types are developed."

Beecher's standing among biologists and paleontologists was high; he was a leader among students of Brachiopoda and Trilobita. His paleontologic work at Yale was essentially of a biologic and philosophic character. He had the artist's gift, nearly all the drawings illustrating his various papers being made by himself and exhibiting a high order of merit. He

was a slow and very careful worker. Those who knew him well saw in him an enthusiast, but his exuberance was always held in check by his judicial qualities, which also made him an excellent counselor. He was orderly in his work, and, as he had the "museum instinct" well developed, he made one of the best of museum curators.

In 1894, Beecher married Mary Salome Galligan of Warren, Pennsylvania, who, with two daughters, survives him. He died very suddenly of heart disease at his home, shortly after one o'clock on Sunday afternoon, February 14. Up to about eleven o'clock of the same day, he was in his usual health. He lies in Grove Street Cemetery, in the shadow of the Sheffield Scientific School.

CHARLES SCHUCHERT.

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ART. XXXIX.—*Dinosaur Footprints from Arizona*; by E. S. RIGGS.

A SLAB of sandstone bearing dinosaur footprints, recently eceived at the Field Columbian Museum, is of interest in narking a new locality for these well-known fossils. The racks were found in the bluffs overlooking the Colorado River,

Dinosaur tracks one-fourth natural size.

iear Lees' Ferry in Northern Arizona. Mr. F. V. Kearn, the ollector, reports that there were six impressions in all, but he ucceeded in preserving only two. The matrix is a sharp, fine-rained sandstone of a bluff color when freshly broken, but veathering to a dark reddish brown. Data as to the geo-ogical horizon are wanting, but it may be assumed that the pecimen is of Triassic age.

The impressions are evidently made by the hind feet of a ridactyl animal similar in structure to those of *Allosaurus* Marsh, but considerably smaller. The tracks preserved are but few inches apart and were apparently made in wet sand. That of the right foot is barely its own length in advance of he left and is separated by a similar distance laterally. It may

therefore be inferred that the tracks were made by a bipedal animal walking leisurely along a sandy beach.

In outline the tracks are almost symmetrical to a line passed through the imprint of the middle digit. The axis of the foot is deflected but little from the line of stride. The middle digit was evidently strongest and bore more than an equal share of the animal's weight. The two lateral digits appear to have been equally functional and, like the middle one, were armed with claws. The inferior surface of the foot was provided with pads similar to those of struthious birds. In digit II the weight was borne upon the first and second phalanges, in digit III upon the second and third, while in digit IV the second, third and fourth were evidently brought to the ground. In addition to this there is an imprint of a heel-like pad which was borne by the distal ends of the metatarsals.

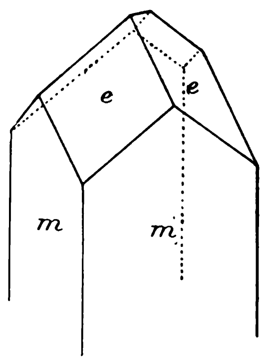
Measurements are as follows:

	M	
Length over all	·128	
Breadth	·103	
Length of lateral digits from heel	·079	
Angle between digits II and III		35°
" " III " IV		30°

ART. XL. — *A New Habit for Chalcopyrite*; by R. W. RICHARDS.

A SPECIMEN of chalcopyrite collected in Somerville, Massachusetts, by Prof. A. E. Dolbear, of Tufts College, some years ago, shows apparently a new and simple habit for the species. The specimen was found in a vein of rusty quartz in the quarry between Broadway and Holland Streets, near Clarendon Hill. The rock of the quarry is the so-called Cambridge or Somerville Slate, referred by some geologists to the Carboniferous, by others to the Lower Cambrian. This rock is a clay-slate cut by many diabase dikes, which in turn are cut by numerous veins carrying a great variety of minerals, among which quartz, calcite, albite, prehnite, babingtonite, erythrite, chlorite and oxides of titanium, recently discovered by Prof. Charles Palache, of Harvard University, may be mentioned.

The crystallization of chalcopyrite is tetragonal, and a sphenoidal habit usually predominates. Prof. S. L. Penfield, in his paper in this Journal on crystals from Chester Co., Pa. (vol. xl, 207, 1890), figured specimens showing prismatic and pyramidal planes, and others showing sphenoid and scalenohedral faces, which he suggests may represent a prism and a second order pyramid distorted by oscillatory combination with the positive sphenoid. The indices he assumes for the distorted forms agree with the forms found on the crystal described in this note.



The Somerville specimen is shown in the cut and possesses only two forms, a prism *m* and a second-order pyramid *e*. These have the indices 110 and 101, respectively, and present the identical faces figured by Prof. Penfield, in a twin crystal (l. c. fig. 8, p. 210). The rough character of the Somerville crystal permitted only contact measurements and the best readings were selected by choice. The angles giving the most satisfactory set of readings are those around the coign *m* to *e*, *e* to *e*, and *e* to *m*. These angles are nearly equal and were found by measurement to be about 60°. This satisfies the relation that should obtain between the planes of the prism and those of the second-order pyramid,

e to *e*,	59° 30·5′
e to *m*,	63° 46·1′.

In Hintze's Handbuch der Mineralogie, sixteen cases are noted of the occurrence of the form *e*, and only seven of *m*. With the exception of one or two cases, either one or the other or both forms are subordinate. The Somerville crystal seems novel in showing these forms predominant and, perhaps, excepting the sphenoid, represents the simplest form of the crystallized mineral.

It is interesting to note that this form differs very slightly from the isometric dodecahedron. This similarity is accounted for by the axial ratio of the mineral, 1 : 0·98525. The resemblance of the crystal to the dodecahedron is well brought out by comparing it with a model of the same. In the drawing and in the crystal itself, the illusion is destroyed by the downward extension of the prism plane.

The crystal is unusually large for the species, having an average diameter of four centimeters. The largest of the Chester County crystals had diameters of a centimeter. Lacroix mentions large crystals from Oued Allelah of Algeria, Africa, having diameters of eight millimeters. The rather indistinct sphenoids from Ellenville, N. Y., have about the same dimensions as the Somerville crystal.

Credit is due to Prof. Palache for assistance in the examination of the specimen and suggestions in regard to its importance.

Tufts College, Massachusetts, 1904.

ART. XLI.—*Molecular Weights of Liquids, with a few Words about Association;* by C. L. SPEYERS.

FOR some years past, evidence has been advanced* to show that

$$\frac{n}{N} = \frac{p-p'}{p'} \tag{1}$$

agrees with experiment far better than

$$\frac{n}{N} = l\frac{p}{p'} \tag{2}$$

does. While (1) is as true for concentrated solutions as for dilute ones, (2) fails both in theory and in fact for concentrated solutions, though of course good for dilute ones.

A theoretical foundation was sought for (1) in the notion that a volatile liquid produces those molecules which pass off as vapor *in the body of the liquid* instead of merely on the surface, a notion which J. Traube† is advancing as one of the results of his study of critical phenomena, and that the vapor tension of a liquid is the result of such differentiation in the liquid.

Moreover, on combining (1) with the second law of thermodynamics we get equations for the molecular rise in boiling point and depression in freezing point, for the molecular heat of vaporization and of freezing, and all these independently of the osmotic theory.

Equation (1) has also been advanced tentatively by S. Young and E. C. Fortey‡ but with some reservations in regard to changes in density. The new mixtures that they used were ethyl propionate with ethyl acetate, toluene with ethyl benzene, n hexane with n octane and toluene with benzene. Slight differences were found between observed pressures and those calculated by (1), but no account was taken of a possible association of the vapor of the solvent and so these differences lose something of their significance. In their paper, the writers correct a mistake made by me. They point out that mixtures of non-associated liquids may have minimum boiling points. I stated they could not, and in this respect was wrong, having overlooked the fact that $\Delta p_2/\Delta t$ could be smaller than $\Delta p_1/\Delta t$ at one temperature while greater at another, both temperatures lying within the range of boiling points of the mixtures.

* Journ. Phys. Chem., ii, 347, 362 (1898); Journ. Am. Chem. Soc., xxi, 282 (1899); this Journal, ix, 341 (1900); xiii, 213 (1902).

† Drude's Ann., viii, 267 (1902).

‡ Journ. Lond. Chem. Soc., lxxxiii, 45, 68 (1903).

A word now in regard to association.

Let us consider water. Its density in the gaseous state leads to a formula for its molecule of H_2O. When metals react with it, we get hydroxides and oxides of the general formula $M(OH)_x$ and M_xO_y. In all chemical respects water behaves as if it had the formula H_2O, two replaceable hydrogen atoms and one replaceable oxygen atom, no more, no less. This formula, therefore, has a chemical, a scientific, significance. It states that in chemical reactions two atoms of hydrogen and one of oxygen go together. But in some physical relations, in those relations which involve water as a liquid and in which it stays a liquid, that formula does not account for things. Water is now not so active as corresponds to H_2O. To bring its activity up to what experience has determined to be the normal, the standard, activity, we must take two, three, or more times the mass corresponding to H_2O. We are, therefore, tempted to say water is associated, and to write $(H_2O)_a$ where a runs up to three or four for water and reaches much higher figures with some other liquids. But in so doing we use an unsuitable formula, because the liquid does not behave chemically as this expression suggests. So it is very undesirable to speak of associated molecules. More definite, and far more in accord with what we know, to say that the activity of the water is depressed below the normal than to say its molecule has been associated. The weak notion of associated molecule is replaced by the virile notion of activity. We shall call the above quantity denoted by a, the activity factor. *The activity factor* a *denotes the number of normal grammolecules which must be taken to give an activity equal to the normal, or standard, activity, the standard activity being determined by experience.* We are not to consider a as constant for any liquid but to vary with the conditions as well as with the liquid, and so the objection made by Young and Fortey* that (1) gave values for n which meant $a>1$ in certain mixtures of liquids for which in the pure state $a = 1$ is not valid.

The increased activity beyond the normal, which means $a<1$, called electrolytic dissociation or ionization, is another matter. There are regularities here which enable us to cast the processes into chemical equations. This we cannot do when $a>1$. When $a<1$ we find a chemical activity beyond the normal, so when $a>1$ we may by analogy look for a depressed chemical activity. This idea has not yet been put to the test.

Consider two volatile liquids, 1 and 2, not miscible in all proportions within certain limits of temperature and without chemical action the one upon the other. Let n_1, n_2, denote the

* l. c., 46.

number of grammolecules of each liquid when considered as solute; N_1, N_2, the number of grammolecules of the same liquids when considered as solvent, in computing which the ordinary molecular weight in the vapor state is to be used; p_1, p_2, the vapor tensions of the pure liquids; p_1', p_2', p_1'', p_2'', the vapor tensions of the same liquids in the solutions. Here and elsewhere the two coexisting solutions or phases are distinguished by $'$ and $''$.

At some fixed temperature let us add liquid 1 to a fixed quantity of 2. We have for the two components

$$\frac{n_1'}{N_2'} = \frac{p_2 - p_2'}{p_2'}; \quad \frac{n_2'}{N_1'} = \frac{p_1 - p_1'}{p_1}$$

which hold until the phase disappears entirely. When, on continued addition of 1, a second phase appears, we have the additional two equations

$$\frac{n_1''}{N_2''} = \frac{p_2 - p_2''}{p_2''}; \quad \frac{n_2''}{N_1''} = \frac{p_1 - p_1''}{p_1''}.$$

Since the phases are in equilibrium, $p_2' = p_2''$, $p_1' = p_1''$, and so

$$\frac{n_1'}{N_2'} = \frac{n_1''}{N_2''}; \quad \frac{n_2'}{N_1'} = \frac{n_2''}{N_1''}$$

The proportion of 1 to 2 is different in each phase, wherefore the activity factor, a, for each liquid must be different in each phase. Moreover, the quantity of 1 in 2 being greater in the second phase than in the first, the activity factor, a, is greater in the second phase than in the first, while $a_2' > a_2''$. A jump then in the mutual effects of two liquids, the one upon the other, accompanies the formation of two liquid phases, a jump in the effect of 1 upon 2 being balanced by the jump in the effect of 2 upon 1.

Following custom, we call that temperature above which two liquids dissolve in each other in all proportions, the critical temperature of solution, or for shortness just critical temperature. The composition belonging to the critical temperature we call critical composition and a solution of such composition a critical solution.

Let us start above the critical temperature with a solution of critical composition and with liquid 1 as solute, 2 as solvent, and cool the solution. As we pass down through the critical temperature, the homogeneous liquid separates into two phases, and as the change due to lowering the temperature is continuous, at a temperature infinitesimally below the critical temperature, the compositions of the two phases are only infinitesimally

different, and so their volumes, within an infinitesimal difference, are each one half the original volume, as has been shown by Konowalow.* As we pass on downwards below the critical temperature, the compositions of the two phases diverge, the divergence sometimes increasing indefinitely, sometimes diminishing at lower temperatures with promise of forming later on a homogeneous liquid with a second set of critical quantities.†

Let a_1 be the activity factor of liquid 1, m_1 its normal molecular weight, w_1 its mass in the phase under consideration. Let $t°$ be below the critical value. From 1 we get

$$a_1' = \frac{w_1'}{m_1 N_2'} \cdot \frac{p_2'}{p_2 - p_2'}, \text{ and } a_1'' = \frac{w_1''}{m_1 N_2''} \cdot \frac{p_2''}{p_2 - p_2''}. \qquad (3)$$

Since two phases are present, w_1' and N_2' as well as p are variable with t and so

$$\frac{da_1'}{dt} = \frac{1}{p_2 - p_2'} \cdot \frac{1}{m_1 N_2'} \left[\frac{w_1'}{p_2 - p_2'} \frac{p_2 dp_2' - p_2' dp_2}{dt} + \frac{p_2'}{N_2'} \frac{N_2' dw_1' - w_1' dN_2'}{dt} \right], \text{(4}$$

where dp_2'/dt is the differential coefficient of the vapor tension of the solution in the immediate neighborhood of the value p_2'; dp_2/dt, that of the pure solvent in the immediate neighborhood of the value p_2. With the exception of

$$\frac{p_2 dp_2' - p_2' dp_2}{dt} \text{ and } \frac{N_2' dw_1' - w_1' dN_2'}{dt}$$

the signs of all the quantities are positive. For dilute solutions we shall put dp_2'/dt from the solution, approximately equal to dp_2'/dt from the pure solvent. That is, we shall assume that dp_2'/dt from the dilute solution is quite close to what we should get were we to differentiate the vapor tension from the pure solvent in the immediate neighborhood of the numerical value p_2'. We do this because we find that in dilute solutions, while the vapor tension curve of the solvent is depressed numerically it is not altered in character, and because we seek the sign of the first quantity rather than its numerical value. With this understanding we find

$$\frac{p_2 dp_2' - p_2' dp_2}{dt} > 0$$

for water, methyl alcohol, i butyl alcohol, amyl alcohol, i amyl alcohol, i butyric acid, carbon disulphide, benzene, and chlorbenzene, and probably for all dilute solutions. Its numerical

* Drude's Ann., x, 360 (1902).
† Ostwald, Lehrb. ii, 670 (1902).

value is not large and does not seem to change rapidly. The other quantity we find is positive when $dw_1'/dt>0$, for then by the nature of the case $dN_2'/dt<0$, and negative when $dw_1'dt<0$ for then $dN_2'/dt>0$. Since $w_1'+w_1''=w_1$ a constant, we have both cases so long as the two coexistant phases are present. For the more dilute phase with respect to 1 $dw_1'/dt>0$, for the more concentrated phase $dw_1''/dt<0$. For this one we write similarly to (4)

$$\frac{da_1''}{dt}=\frac{1}{p_2-p_2''}\cdot\frac{1}{m_1N_2''}\left[\frac{w_1''}{p_2-p_2''}\frac{p_2dp_2''-p_2''dp_2}{dt}+\frac{p_2''}{N_2''}\frac{N_2''dw_1''-w_1''dN_2''}{dt}\right]. \quad (5)$$

From 1,

$$\frac{w_1''}{p_2-p_2''}=m_1\frac{N_2''}{p_2''}$$

which substituted in (5) gives for the bracketed part

$$m_1\frac{N_2''}{p_2''}\left[\frac{p_2dp_2''-p_2''dp_2}{dt}+\left(\frac{p_2''}{N_2''}\right)^2\cdot\frac{1}{m_1}\cdot\frac{N_2''dw_1''-w_1''dN_2''}{dt}\right]$$

The solution now being concentrated, we cannot predict much about the first term from a study of the vapor tension of the pure solvent. I think, however, we may assume that the numerical value of this term will not change rapidly compared with the other term. The second term changes rapidly because it is the arithmetic sum of two quantities, not the difference, and because it has in addition a factor which is the square of a fraction whose numerator and denominator both increase as t increases. Consequently, for quite a wide range in concentration we may look for a negative value for the quantity in brackets and therefore expect

$$\frac{da_1''}{dt}<0 \quad (6)$$

while for the less concentrated solution

$$\frac{da_1'}{dt}>0 \quad (7)$$

At the critical temperature, dw_1'/dt, dw_1''/dt, dN_2'/dt, dN_2''/dt all reduce to zero, and so from (4) and (5),

$$\frac{da_1'}{dt}=\frac{da_1''}{dt}=\frac{da}{dt}=\frac{w_1}{m_1N_2}\cdot\frac{1}{(p_2-p'_2)^2}\cdot\frac{p_2dp_2'-p_2'dp_2}{dt}. \quad (8)$$

The solutions being concentrated we cannot predict at all concerning the sign of da/dt from the vapor tension curve according to temperature of the pure solvent, and the data at hand for the vapor tensions of the solutions are limited to a few

cases to be considered after we remark that a set of equations exactly similar to (3), (4), (5), (6), (7) and (8), hold for liquid 2, the two sets of equations being connected by the relations

$$w_1' + m_1 N_1'' = w_1$$
$$w_2'' + m_2 N_2' = w_2.$$

The cases in question are mixtures of anilin with amylene (trimethyl ethylene), and nitrobenzene with methyl iodid, with amylene, with ether, and with pentane, all investigated by Konowalow.* Only the first and last however gave coexistent phases. The others were above their critical temperatures. The highest temperature of the anilin mixture being 25·1° only the amylene was supposed to have an appreciable vapor tension and we are limited to the activity factor of the anilin only. For a similar reason we can find the activity factor of the nitrobenzene only, the temperature of the mixtures containing it being 18·1°.

I

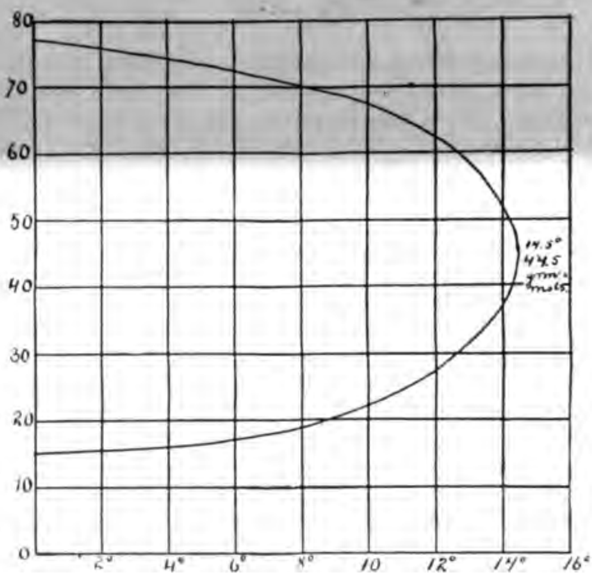


Figure 1 shows the compositions of the two coexistent phases for the anilin mixture from the critical temperature 14·5° down. The critical composition is 44·5 per cent grammoleculеs of anilin.

The following table contains the data necessary for finding the activity factor of the anilin. In it $t°$ is the temperature, p

* l. c.

the vapor tension of the pure amylene at $t°$, p' the vapor tension of the amylene from the solution, n the per cent grammolecules of anilin in calculating which the normal molecular weight of 93 is used, and a the activity factor computed according to (3) using 70 as the molecular weight of amylene. Should the vapor density of amylene be other than what corresponds to 70, the value for a would have to be correspondingly changed.

$t = 0°$ $p = 180·6$mmHg

n	p'	a
10·9	168·9	1·8
[15·0]	164·8	1·8
[77·5]	"	36
81·5	162	38

$t = 8·1°$ $p = 257·8$mmHg

n	p'	a
10.9	241·5	1.8
[19·0]	238·1	2·8
[69·0]	"	27
75	234	29

$t = 14·1°$ $p = 331·0$mmHg

n	p'	a
7·5	315·0	1·6
20	308·3	3·1
25·3	303·0	3·7
31·1	303·2	4·9
[37·0]		
42·2	301·8	7·5
45·5	302·0	8·7
50·7	302·6	11
[51·0]		
59·8	303·1	16
65·3	301·0	19
75	291·6	22
80	273·0	19

$t = 18·1°$ $p = 391$mmHg

n	p'	a
24·2	354·9	3·1
35·1	352·2	4·9
49	351	8·4
69·9	342·7	16
73·1	336·5	17
82	303·1	16

$t = 25·1°$ $p = 498·9$mmHg

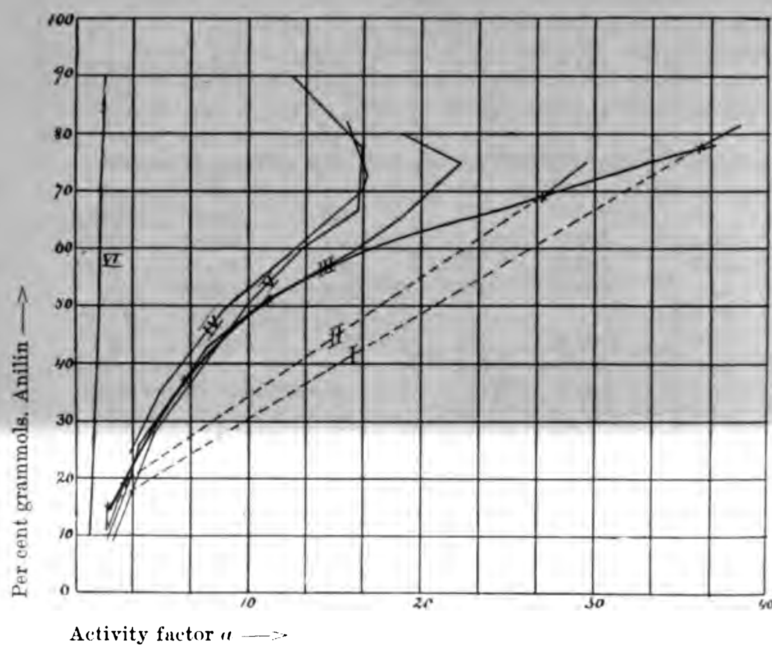
n	p'	a
9.2	476·6	2·2
28·2	458·9	4·5
49·2	453·8	9·7
50·1	453·1	9·9
59·8	447·9	13
66·7	444·2	16
77·7	411·8	16
89·7	295·4	13

From figure 1 we see that at 0° the two layers have the composition of 15·0 and 77·5 per cent grammolecules. These values have been enclosed in [ ], Konowalow giving the vapor tension but not the corresponding compositions. Similarly for the phases at 8·1°. Two phases should have formed at 14·1° but they do not seem to have become visible.

The values for a have been plotted in figure 2. The crosses × mark the compositions of the coexistent phases. Plot 1 corresponds to 0°. We observe that in the phase dilute with respect to anilin, the activity factor is small, only about 2, that is, the anilin is comparatively active, but when the per cent of anilin is large, the activity factor is very large up to about 36 so that now the anilin is very inert. At 0° then we may expect to find dilute solutions of anilin in amylene more active

chemically with respect to the anilin than concentrated ones in amylene. Similarly for plot II at 8·1° and for plot III at 14·1° up to about 75 per cent grammolecules of anilin. From that concentration on and at a temperature around and beyond the critical temperature, the activity factor begins to diminish again, indicating that pure anilin has a greater activity than when in concentrated solutions in amylene.

2



I at 0°, II at 8·1°, III at 14·1°, IV at 18·1°, V at 25·1°.
VI. In $(C_2H_5)_2O$ at 16·2°.

At low concentrations, up to 15 per cent grammolecules of anilin, a increases with the temperature, in accordance with what is stated after equation 4; but at high concentrations, so long as two coexistent phases are present, the reverse is the case, a diminishes as the temperature increases, which is in accordance with what follows after 5. When the temperature rises to 18·1° and the two coexistent phases disappear we find a increasing with the temperature so that in this concentrated solution,

$$\frac{p_2 dp_2' - p_2' dp_2}{dt} > 0$$

just as it would be for pure amylene.

The parabola-like curve shows how a changes with the temperature for pairs of coexistent phases. The dotted lines of I and II connect the coexistent phases. The two ×'s of III are not connected by a dotted line, because the values of the intermediate compositions and pressures are given by Konowalow. He points out that at the temperature to which this curve belongs, which temperature is very close to the critical one, p' varies very slightly with the composition for a range between 25 and 60 per cent grammolecules of anilin, whereas, according to figure 1, this should only be so between the limits of 37 and 51 per cent. We account for this quite readily, by the increasing value of a. Plot VI has been taken from a previous article.*

The following table contains the other data from Konowalow.

Nitrobenzene in methyl iodid.
$t = 18{\cdot}1°$ $p = 310{\cdot}7$mmHg

n	p'	a
19·7	260·5	1·3
40	210·7	1·4
50	185·4	1·5
66·6	137·1	1·6
82	79·5	1·6

Nitrobenzene in amylene.
$t = 18{\cdot}1°$ $p = 391$mmHg

n	p'	a
16·5	351·2	1·7
32·3	332·9	2·7
41·6	323·7	3·3
59·9	294·8	4·6
66·6	263·8	4·1
78·8	207·9	4·2

Nitrobenzene in ether
$t = 18{\cdot}1°$ $p = 416$mmHg

n	p'	a
16	359	1·2
40·3	294·6	1·6
50·9	261·6	1·8
59·1	232·3	1·8
63·9	215·7	1·9
66·6	203·5	1·9
75	166·3	2·0
76	160·9	2·0
86·6	98·7	2·0
92·5	59·5	2·1

Nitrobenzene in pentane.
$t = 18{\cdot}1°$ $p = 536{\cdot}3$mmHg

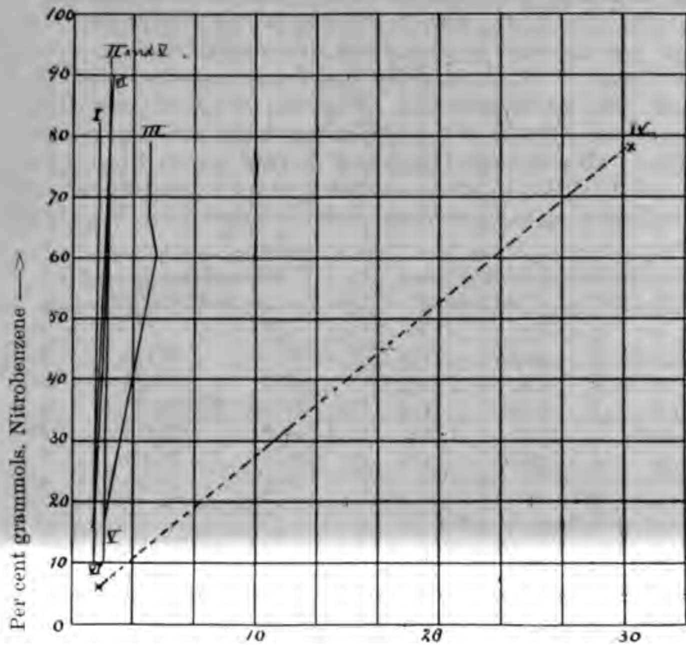
n	p'	a
5·9	514·3	1·5
two layers	504·0	
78·2	479·6	30

These data have been plotted in figure 3. The activity factor of nitrobenzene is pretty constant in methyl iodid and in ether, in amylene it increases considerably as the nitrobenzene increases, while in pentane the increase is 20 times what it was at the beginning. In this case, however, we have two coexistent phases. Unfortunately, the compositions of the coexistent phases are not given, only one composition before the coexistent phases have formed and one after the coexistent

* Journ. Phys. Chem., ii, 347 (1898).

phases have disappeared. The extremities of the broken line of IV mark the compositions of these solutions. I have added plots V and VI taken from an earlier article.* They fit in

3



Activity factor a ——>
I. In CH_3I. II. In $(C_2H_5)_2O$. III. In $(CH_3)_2C{:}CH(CH_3)$.
IV. In C_5H_{12}. $t^\circ = 18{\cdot}1^\circ$.
V. In CCl_4 $t^\circ = 34.8$. VI. In $(C_2H_5)_2O$ $t = 16.2^\circ$.

very well with these of Konowalow and together with VI of figure 2 show how characteristic of two coexistent phases the big jump in the activity factor is.

* l. c.

December 11, 1903.

ART. XLII.—*The Relation of Mass Action and Physical Affinity to Toxicity, with incidental discussion as to how far electrolytic dissociation may be involved;* by J. B. DANDENO.

MASS action, as a principle underlying chemical phenomena, is comparatively well established. The law may be briefly stated, that when any substance in a dissolved state enters into a chemical reaction, the amount of the action is proportional to the active mass of the substance. By mass of substance in solution, or molecular concentration, is meant the number—not actual but relative—of molecules per unit of volume. It may be expressed as so many gram-ions per liter of solution. An illustration of mass action is here given. When potassium nitrate and sulphuric acid are mixed in solution, a reaction, depending upon the mass of each in solution, takes place. Thus, if the acid be in excess, the resulting products are potassium bisulphate ($KHSO_4$) and nitric acid; but if a large excess of nitric acid be added to potassium bisulphate, the resulting products are H_2SO_4 and KNO_3. Such phenomena, though common enough in chemistry, are not well understood.

In this paper an effort is made to set forth one point of view from the physiological side. The radicles of some seedlings are used as the physiological reagent, and a few common solutions as the chemical; and silica to represent a possible physical agent.

By physical affinity is here meant the force of attraction, without chemical change, that substances may have for one another in solution. As will be shown in some of the experiments described in this paper, there is a very considerable amount of such attraction. It has been pointed out* that, with certain toxic solutions, the toxicity was much reduced when non-chemical† substances were present. But just to what extent such non-chemical substances have to do with the well-being of plants, little is at present definitely known. From this it is not to be inferred that such effects are the only effects which may result from the presence of non-chemical substances. It is this action alone,—this hindrance to the chemical action (which would take place if the non-chemical substance were not present)—which is here considered.

The importance of this is at once apparent, when one considers that the great mass of soil particles are non-chemical in their

* Dandeno, Trans. Can. Inst., vii, p. 315.

† By non-chemical substances is here meant those substances which do not react chemically in the experiment in question, and which are not soluble in the liquid used.

nature. The question of fertilizers—one of the most important to the farmer—is essentially a part of this question. For, if the particles of soil can mechanically hold substances in solution, then there will always be a certain amount in the soil which is not available to the roots of the plants. Moreover, roots will be able to withstand a greater amount of poisonous substance in the soil than they could if immersed in a liquid. There are numerous suggestions which may arise along this line, but the discussion in this paper is confined to two phases of the aspect,—(1) that of the inhibitory effects produced by pure sand upon toxic solutions, and (2) that of the relative effects, in the same regard, of fine and of coarse particles.

Considerable has been done within the last eight or ten years towards determining at what concentration of solution certain seedlings will survive, when the radicle is immersed in the solution for a given period of time. Kahlenberg and True,* 1896, record a large number of experiments made with *Lipinus albus*, and deduced certain results, some of which are quite probably unwarranted. Their general method of preparing solutions, a departure from the percentage method, is to be commended, though some confusion in regard to naming of solutions, and other errors of chemical formulæ, make it necessary to be cautious about accepting their results. Heald,† in the same connection, worked with seedlings of *Zea mais*, *Pisum sativum* and *Cucurbita*, but unfortunately confused matters somewhat in the same manner, so that one cannot reconcile his table summarizing results, with the individual tables. For example, on page 152, Heald gives the limit which for corn, just allowed growth as 1/102400 *eq.*, $CuSO_4$; while on page 140, same paper, he records for the same seedling a growth of 16·5 and 7^{mm} (for two successive days) in a solution of $CuSO_4$ 1/102400 *mol.* It seems a pity that more care was not taken in this regard. Stevens‡ worked with spores of a few fungi; and Loew§ gave results of experiments made with seedlings of indian corn.

True and Gies‖ worked with mixed solutions and this work bears somewhat upon the line of thought followed through a part of this paper. True¶ recorded the results of a large number of experiments with *Lupinus albus* along a similar line to that pursued by Kahlenberg and True. True and Hunkel** used certain of the phenols in a similar connection.

Moreover, the same problem has been touched upon from another point of view. O. Loew†† discussed the question of

* Bot. Gaz., xxii, 1896.
† Bot. Gaz., xxii, 1896.
‡ Bot. Gaz., xxvi, 337, 1898.
§ Science, Sept. 4, 1903, p 304.
‖ Bull. Torr. Bot. Club, xxx, 390, 1903.
¶ This Journal (4), ix, p. 184, 1900.
** Bot. Cent., lxxvi, p. 9.
†† U. S. Dep. Ag., Bull. 18, 1899.

the function of certain of the mineral salts in the soil. Plowman* dealt with the question from the standpoint of electricity and magnetism, using plants growing in flowerpots. He concluded that ionization of the soil bore directly upon growth of plants. Cameron† deals with the same question mainly from the point of view of soils and crops. Clark‡ pursued a line of work similar to that of Stevens.

It is not the intention to give a complete historical bibliography of the subject, but rather to mention some of the more prominent work done directly along this line in order that correlation of data may be available. Due acknowledgment will be made of the work of each in its proper relation to this discussion.

The aim of most of those authors seems to have been to determine, for certain solutions, the concentration at which organs or organisms would just live, or just not live. Nothing apparently is said as to whether quantity of solution had anything to do with the life of the organism. Nor is anything said of the question as to whether the shape of the vessel, or the presence of foreign non-chemical bodies might have any influence upon the action of the substance in solution. The quantity of solution used was apparently considered of little importance by some of those who made experiments along this line, for little or no mention is made of quantity. Cameron (Bull. 71) and Loew (l. c.), however, are clear on this point.

The method of preparing solutions was in strict accord with the plan of chemical equivalents, that is to say, the solutions were so prepared and named that n stands for a gram-equivalent per liter of solution in each and every case. The number in the denominator of the fraction whose numerator is n, denotes the concentration of the solution under consideration. Where the acids or salts are monobasic, the gram-molecule is the same as the gram-equivalent; where the acid or salt is dibasic, then one-half the molecular weight to a liter is the gram-equivalent. It is not necessary to mention acids or salts of other basicity, as the two mentioned are the only kinds used in the experiments here described. In the case of the so-called acid salt ($NaHCO_3$), one-half the molecular weight in grams dissolved to a liter is the gram-equivalent per liter solution,—exactly similar in concentration to that of the carbonate (Na_2CO_3). This may seem unduly explicit on this

* This Journal (4), xiv, p. 129, Aug., 1902.

† (*a*) U. S. Dep. Ag., Bur. of Soils, Bull. 22, 1903.

(*b*) Jour. Phys. Chem., viii, 1, Jan., 1904.

(*c*) Bull. 71, U. S. Dep. Ag. This contains a particularly valuable discussion of the matter, Kearney being associated with Cameron in the work.

‡ Bot. Gaz., xxviii, p. 409.

point, but it is necessary to be so, considering some work which has been done along a similar line. For example, True* states, referring to H_2SO_4: "And since it splits off two H ions from every molecule, it would have in chemically equivalent quantities twice the number of H ions found in HCl." The author just referred to evidently had an erroneous view as to what chemical equivalent quantities meant, although he had previous to this published some papers (one of which has already been referred to) on a similar character of work. Hence it may be seen that care, both in preparing and in naming solutions, is very desirable.

The solutions used in the following experiments were selected because they represent the chief types,—acid, base, and toxic salt. The carbonate and the bicarbonate were used in order to see how physiological reactions might harmonize with the theory of electrolytic dissociation. Carbonic acid presented a peculiar aspect of the question, inasmuch as it is an acid which is said to dissociate, and yet it produces almost no toxic effect at the highest concentration obtainable.

The method of marking and of measuring the radicles, and the test applied to decide the question of death, were according to the method of Loew[8], namely, that of a growth in water after having been submitted to the solution test. If growth took place in the solution, and then in water, the radicle was considered living; but if no growth took place in water—after the twenty-four hours in the solution—the radicle was considered dead. For measuring the growth of the pea and the corn, a mark was made on the glass vial on one or both sides; then sighting through in line with the root tip, measurement could thus be made very accurately, and certainly very conveniently. In the case of the lupine, a mark was made with india ink at, or a little below, the junction between the root and stem; and this mark kept above the solution. Measurement was made from this mark to the end of the root tip and recorded.

An attempt was made to follow the method of marking adopted by Heald, and Kahlenberg and True, but it was found too clumsy for the purpose, mainly for the reason that the india ink would "run" so as to leave the mark upon the root broad and indefinite, and in some cases the mark was entirely lost when the portion of the radicle on which the mark was made was in the solution.

The seedlings used were *Zea mais* (common field corn, yellow dent variety), *Pisum sativum* (small field pea) and *Lupinus albus* (white lupine). These were selected chiefly because they were convenient for the purpose; and also because other inves-

* This Journal, vol. ix, March, 1900, p. 184.

tigators had worked with the same kind of seedlings, rendering comparison of results possible. Seedlings were prepared in the usual way, and were used when the radicle was of a suitable length. However, none was used whose radicle was less than 12^{mm} in length.

For the test in regard to physical affinity, a pure sand was obtained from ground quartz. This was thoroughly washed, first in strong HCl, then in water, and lastly in distilled water several times. Two grades were secured, *fine* and *coarse*. The particles of the fine sand were of such a size that the volume of one grain was $\cdot 0655^{cbmm}$, and a grain of the coarse sand $\cdot 22^{cbmm}$. The surface area of the fine sand is to the surface area of the coarse sand, therefore, as 3 : 2, in a given mass of sand. From this it is not to be inferred that all the grains were exactly of the same size. The measurements given are an approximation towards an average. A further test was made to see how great the volume of air space would be in the one as compared with that of the other. The following was the result of careful experiments: In a total volume of $15{\cdot}6^{cc}$, there was, in the case of the fine sand, $5{\cdot}6^{cc}$ of air and 10^{cc} of sand. Of the coarse sand, in a volume of $15{\cdot}6^{cc}$, there were $6{\cdot}0^{cc}$ of air. Both were tested as nearly as possible under the same conditions of packing. Several tests gave the same result. It thus appears that the coarse sand contained a little more air space than did the fine,—actually 38·4 as against 35·9 per cent, in proportion to total mass of sand and water.

The volume of sand used per seedling was 12^{cc}, and 8^{cc}, in the case of both kinds of sand. As no difference was observed in regard to growth whether the quantity was 12^{cc} or 8^{cc}, no mention is made in the records.

Some of the experiments seemed to show that the shape of the vessel in which liquid tests were made had a perceptible influence upon the power of the seedling to resist the toxic action of the solution, resulting possibly from inequality of diffusion. But in all tests recorded in this paper, the vessels were homeopathic vials of uniform proportions for all the sizes (from 25^{cc} to 1^{cc} capacity).

For corroborative tests, the seedlings were germinated in calcium chloride tubes, the "seed" remaining in the bulb and the radicle growing down through the small end. Manipulation was thus very convenient, and the minimum of damage done the seedling in the process of transfer and of marking. This test was made only with seedlings whose radicles had penetrated *beyond the end of the tube.*

The different tests used by the various investigators to decide death renders it extremely difficult to make comparisons. The

test here, as has already been stated, is the capability of making further growth. In nice distinctions the mere appearance is not a sufficient test; but strange as it may seem, this has been the most general criterion. However, in the most critical point this test fails. Jones (Theory of Elect. Chem., p. 269) states: "It was a simple matter to determine when the root was dead, since it lost its satiny lustre and acquired a dead white color." This is just what it is almost impossible to do. Cameron* gives it as a test of death that when the first 15^{mm} became flaccid, death resulted. From this it may be inferred that, if the radicle became flaccid the first 13^{mm}, or the first 10^{mm}, or even the first 5^{mm}, the seedling would be recorded as *living* in that solution. Where the radicles did not become flaccid at death he does not say how he decided the matter. He contents himself with saying that it required *much experience* and *nice judgment.*

Vagueness is occasional even in measuring. Kearney and Cameron (l. c.) state: "The radicle had somewhat elongated from the plumule to the apex." They may mean from the terminal bud to the apex of the root; or, possibly from one end of the radicle to the other, two very different things.

The tables contained in this paper (unless otherwise stated) are records of *average* experiments of each type. It would occupy far too much space to give all the records, because a large number of experiments were made in each class, often as many as twenty seedlings being submitted to the test. Experiments were frequently repeated, sometimes out of mere curiosity, but all the evidence obtainable was used to strengthen whatever results are here set forth. One or two seedlings, in a test of this nature, is not enough. Occasionally a seedling will die, even in water, and it is extremely difficult to tell why.

To show an example of the comparisons of growth made in regard to quantity of solution used, one experiment is here below recorded.

I.

PEA, HCl $n/2048$.

Quantity of solution.	Growth in 24 hours in solution.	In water, growth in 24 hours.
25^{cc}	0^{mm}	0^{mm}
20	0	0
12	0	0
8	0	0
5	3	0
$2\frac{1}{2}$	12	11
1	12	16

Such experiments as the one whose results are just given form the basis for the figures in Tables II–IX.

* Journal Phys. Chem. xiii, 3, 1904.

The columns in the following tables (I–IX), under concentration used, are divided into four parts, and these are subdivided,—A, B, C, D. In the column A is given the number of cubic centimeters in which the radicles plainly lived and grew. In B is given the number of cc. in which the radicles died. Column C contains the average number of mm. the radicles grew during twenty-four hours' immersion in the solution used. This number is not the maximum average, that is to say, it is not a measure of the growth which might be obtained in a quantity of solution much less than the one given in column A. In column D is recorded the average growth obtained in twenty-four hours when the radicle was in water, after having been taken from the solution. This also refers to the seedlings grown in a quantity as indicated in A.

II. H_2SO_4.

	n/1024				n/2048				n/4096				n/8192			
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
Pea					2½	5	5	5	5	8	7	4	12	25	3	0
Lupine					5	8	5	7	12	20	2	6	25		7	9
Corn	1	2½	5	14	12	20	5	10	20	25	5	2				

III. HCl.

	n/1024				n/2048				n/4096				n/8192			
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
Pea					2½	5	12	13	5	8	8	4	12	20	8	2
Lupine					2½	5	12	22	5	8	3	8	20	25	8	3
Corn	1	2½	8	10	2½	5	12	10	12	20	6	3	25		13	3

IV. H_2CO_3.*

	n/171				n/343				n/513			
	A	B	C	D	A	B	C	D	A	B	C	D
Pea					20	25	11	12	25		12	15
Lupine	25		7	3								
Corn	25		16	35								

V. $CuSO_4$.

	n/32768				n/65536				n/131072				n/262144			
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
Pea	2½	5	16	0	8	12	18	0	12	20	4	0	25		10	6
Lupine	5	12	4	6	25		7	30								
Corn									1	2½	8	13	20	25	7	8

* This is considered a divalent acid, though Cameron regards it as a monovalent acid (HCO_3).

VI. KOH.

	n/64				*n*/128				*n*/256				*n*/512			
•	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
Pea									4	8	11	4	25		15	12
Lupine					4	8	11	8	25		12	13				
Corn	1	2½	6	4	25		13	11								

VII. NaOH.

	n/64				*n*/128				*n*/256							
	A	B	C	D	A	B	C	D	A	B	C	D				
Pea					3	8	7	8	25		8	12				
Lupine	1	2½	3	10	25		9	6	25		12	10				
Corn	2½	5	12	15	25		19	16	25		16	12				

VIII. Na_2CO_3.

	n/32				*n*/64				*n*/128				*n*/256			
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
Pea													12	25	10	7
Lupine									8	20	10	5	25		8	9
Corn					12	20	10	5	20	25	8	3	25		6	4

IX. $NaHCO_3$.

	n/8				*n*/16				*n*/32				*n*/64			
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
Pea					3	8	3	2	8	12	7	11	12	20	3	6
Lupine					20	25	4	5	25		5	6	25		13	35
Corn	1	2½	3	8	25		7	6	25		9	20	25		12	42

During the course of many of the experiments made with radicles immersed in solution, certain phenomena seemed to indicate that the action which took place between the substance in solution and the radicle was chemical in its nature. Consequently, experiments were made to ascertain, if possible, how much reaction the radicle might produce if allowed to react upon the solution for a given time. Two of these experiments are here recorded, one of them employing HCl, *n*/1024 and the other H_2SO_4, *n*/1024. In both cases corn seedlings were used. In column 1 is given the volume of solution used in each case; in column 2 is given the growth in millimeters of the radicles during twenty-four hours; then these seedlings

were taken from the solution and fresh seedlings put in their places in the same solution. In column 3 is recorded the growth of seedlings during one day,—the second day the seedlings were used. These were, of course, the same solutions which had been used the previous day. This was continued for eight days. In column 6 is the recorded growth for two days. In all other cases the growth is for a period of twenty-four hours. The same solutions, therefore, were employed for eight days, and seven series of fresh seedlings were used in the test.

X. Corn, HCl, $n/1024$.

1. Quantity of solution.	Growth at the end of,—						
	2	3	4	5	6	7	8
	1 dy	2 dy	3 dy	4 dy	6 dy	7 dy	8 dy
25^{cc}	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0
12	0	0	0	17	12	8	23
8	0	0	0	14	20	13	28
5	0	8	3	9	10	*	*
2½	0	8	20	22	18	*	*
1	8	10	2	24	*	*	*

XI. Corn, H_2SO_4, $n/1024$.

1. Quantity of solution.	Growth at the end of,—						
	2	3	4	5	6	7	8
	1 dy	2 dy	3 dy	4 dy	6 dy	7 dy	8 dy
25^{cc}	0	0	0	0	0	0	0
20	0	0	0	0	8	5	10
12	0	0	0	6	6	8	25
8	0	0	10	24	16	7	24
5	0	14	15	22	8	*	*
2½	0	12	30	22	20	*	*
1	5	14	13	20	*	*	*

From these tables it seems reasonably clear that *quantity* of solution bears certain relations to toxic action. In Table I is shown a sort of limit in quantity, somewhere between 2½ and 5^{cc}, the seedlings plainly living in quantities of 1 and of $2\frac{1}{2}^{cc}$; while they just as plainly died in quantities ranging from 5^{cc} up through 25^{cc}. The action is probably a chemical one, resulting from the substances supplied to the solution by the plant; or, it may possibly be a physical action produced upon the solution by merely extracting certain substances mechanically from the solution. It is by no means easy to decide which

* No tests were made, as growth was quite evident.

it may be. In each case the toxic action of the solution is reduced; in the former by neutralization and in the latter by extraction of the harmful element. This is plainly shown in Tables X and XI. Each seedling makes the solution less toxic, as is shown from the fact that on the first day the seedlings lived in a quantity of 1^{cc} in the case of both acids, while on the eighth day they lived in a quantity of 12^{cc}.

Larger quantities than 25^{cc} were used, but no difference was noticed. In fact, when two or three seedlings were placed in a beaker (100^{cc}) with radicles immersed, it usually happened that they stood the concentration better than when placed singly in vials containing only 25^{cc} of solution.

Small quantities, as a rule, gave the most clear-cut reactions, probably because of the fact that diffusion in solutions is so very slow, making it possible for a considerable quantity of the solute or of the ions to lie in a part of the solution too far from the radicle of the seedling, to affect it. But in the case of small quantities, diffusion will enter into the problem to no very great extent, rendering it possible to obtain results which are more nearly accurate from a chemical point of view.

The actual amount of toxic ions overcome in 24 hours by a seedling of corn with H_2SO_4 and HCl is 1^{cc} of $n/1024$, giving a result of $1/000 \times 1/1024 = 1/1024000$ grams of ionic hydrogen. This may be expressed in another way:—1,024,000 seedlings would resist the toxic action produced by one gram of ionic hydrogen. It may be proved absolutely, as indicated in Table II, column A, of a concentration of $n/1024$. For, if a gram-equivalent solution be diluted to $n/1024$ and divided up into quantities of 1^{cc}, and a seedling be placed in each, they would all grow; but if divided up into quantities of $2\frac{1}{2}^{cc}$, and a seedling placed in each, they would all die. For more dilute solutions, the seedling can live in the presence of a far greater amount of ionic hydrogen, showing that diffusion is remarkably slow and that the action of the mass of the water is considerable. The number of gram-ions in a solution $n/2048$ would be half as many per unit of volume; but the corn seedling lives when submitted to 12^{cc} of this solution. It ought, however, to withstand only 2^{cc}, if diffusion were perfect and mass action eliminated. Consequently, the injurious ions in 10^{cc} of the 12^{cc} used are prevented from acting upon the radicle from the fact that the mass of liquid is great enough to render $10/2 \times 1/102400$ grams of ionic hydrogen harmless, when in a quantity of 12^{cc}. This is the condition of affairs with corn for H_2SO_4. It is apparently different with HCl at the dilution mentioned but similar at the next lower dilution. Where the seedling is particularly sensitive to the solution, as with the pea, there is small difference in relatively great concentra-

tions, the difference being greater and greater as the amount of solution increases. So that beyond a certain limit of concentration, no matter how much ionic hydrogen be present, this hydrogen is prevented from acting on the radicle by the mere presence of the mass of water. This is probably because diffusion is so very slow. The corn seedling theoretically should resist 1, 2, 4, 8^{cc} of HCl in the 4 dilutions given in Table III, if diffusion were perfect. But it does actually resist 1, 2½, 12, inf., Table III, so that the difference in quantity due to mass action is represented by the differences between the pairs of numbers in the series thus,—0, ½, 8, inf. Now, in $n/8192$ the lupine or the corn will counteract the harmful ions as fast as they come in contact with the radicle, so that the dilution at which the seedling lived in 25^{cc} may be said to be the dilution where diffusion and vital activity are balanced. The limit of resistance, therefore, for corn is 1^{cc} of $n/1022$; and of 25^{cc} $n/8192$.

It has been pointed out (3, l. c. p. 90) that lateral roots which develop after a seedling is placed in a test solution may live and grow even though the radicle itself be killed. Kahlenberg and True suggest that this is due to a power of accommodation, but this is quite probably not so, because in a number of experiments with seedlings which had withstood one solution, an attempt was made to have them grow in a solution a grade stronger, or in the same solution in greater quantity, but without success. Seedlings showed no power of accommodation. It is more probably due to the fact that the radicle has already partly neutralized the solution, as appears in Tables X and XI.

The strongest solution of carbonic acid (H_2CO_3) which it was possible to obtain was $n/171$ by actual titration test. Seedlings of corn and lupine stood this concentration readily, but the pea did not. With the largest quantity of solution used (25^{cc}) the pea survived in $n/513$ but died in $n/342$.

H_2CO_3, according to the theory of dissociation, may dissociate into H ions and CO_3 ions, or possibly into H ions and HCO_3 ions, more probably the latter, reasoning from such data as we have concerning $NaHCO_3$. Neither case can be true, speaking in the language of the theory of electrolytic dissociation, because, if there were H ions present in such quantity as is indicated by a dissociation into H ions and CO_3 ions, then it would be as toxic as H_2SO_4, but, from those experiments, it can scarcely be one-fiftieth as toxic. The other alternative method of dissociation can not account for this either, for a similar reason. These results are in opposition to the theory of dissociation.

The experiments with sodic carbonate show that the corn seedling endures a solution of $n/128$ in 25^{cc}. From the side of the theory of dissociation this substance should permit

growth at about $n/16$, because sodic chloride, which is about 5/6 dissociated at this concentration, permits growth. The sodium, in the case of NaCl, appears to be but slightly toxic. Nor can the CO_3 ion be very toxic, from Table IV. Whence then this great toxic action of Na_2CO_3? Basing our views upon the theory of electrolytic dissociation, it ought to be about the same as NaCl or Na_2SO_4. But it is far more so. From this it would seem that the theory was insufficient, or possibly erroneous. The explanation, in the writer's opinion, is that the Na_2CO_3 breaks up, in aqueous solutions, into Na_2O and CO_2 and then reacts thus:—$Na_2CO_3 + H_2O = 2NaOH + CO_2$. It would then be practically a solution of NaOH of a concentration identical with that of Na_2CO_3, which was chemically equivalent. This is quite probable from these experiments. If this explanation be correct, the theory of dissociation may give very misleading notions as to the actual condition of affairs.

The bicarbonate of soda affords another illustration. This may dissociate into Na and HCO_3, or into H and $NaCO_3$, or into Na, H, and CO_3. The experiments show that the pea will grow in 25[cc] $n/128$ and in NaOH $n/256$. If the bicarbonate dissociate according to the first plan, the seedling ought to live in a solution about $n/8$; and if according to either of the latter, in a solution of about $n/2048$. It, however, does neither.

Pea seedlings will live in small quantities of the bicarbonate at a strength of $n/16$ and in similar quantities of NaOH at $n/128$, but in chemically equivalent quantities there is just half as much sodium in the bicarbonate as in the hydroxide. They would compare then at about 4:1 in toxicity, the hydroxide being the stronger. But since this substance may dissociate in three ways at least, we may have a dissociation as follows, with possibly an accompanying chemical action; $8NaHCO_3$ produces $Na_2O + 2CO_2 + H_2O$ and 6Na and $6HCO_3$. This might easily give a chemical reaction from Na_2O and H_2O of 2NaOH. Hence from 8 molecules we get 2 molecules of NaOH or 2 OH ions. The ions Na_6 and HCO_3 are probably harmless, judging from Table IV. This is in the language of the theory. These explanations throw some light upon the alkaline reaction on litmus, and other indicators, of the so-called acid salt $NaHCO_3$. Theoretically it ought to react acid, if anything, but practically it reacts rather strongly alkaline.

Similarly also with Na_2CO_3. Theoretically it ought to be neutral, but it actually reacts very strongly alkaline. The explanation, therefore, is, that in the process of dissolving in water, an actual chemical reaction takes place by some rearrangement of the molecules, or groups of molecules, in the solution. The ionization theory does not aid at all, rather the

reverse. Ionization *may* take place, but a further reaction must be assumed in order to account for the phenomena referred to, both chemical and physiological.

In order to test the effects of a foreign body upon the solute, pure clean sand (silica) was mixed with the solution, and the radicle immersed in the mixture. The vials were of similar proportions to those used in the liquid tests. The actual net volume of the sand employed was from 5 to 8^{cc}, and of liquid $3\frac{1}{2}^{cc}$ to 6^{cc}. Each seedling was exposed two days to the mixture, and afterwards tested for further growth in water. One reason for exposing two days instead of one—which was done with the liquid tests—was to make absolutely certain that whatever deductions in regard to power to resist the toxic reagent, should be on the safe side, because some seedlings can endure a solution for one day when they could not for two days.

In column A, under the given concentration, is placed the average number of mm. the radicle grew in length during forty-eight hours; and in column B the average number of mm. the same seedling grew when immersed in water after being removed from the mixture (solution with sand). In one respect, therefore, the test was a severer one than when the seedlings were immersed in the liquid, because they were exposed to the reagent twice as long.

II.a, H_2SO_4.

	n/256		*n*/512		*n*/1024	
	A	B	A	B	A	B
Pea	0	0	14	8	6	10
Lupine	0	0	13	10	13	3
Corn	3	0	22	29	25	15

III.a, HCl.

	n/512		*n*/1024	
	A	B	A	B
Pea	6	2	27	10
Lupine	4	5	24	6
Corn	29	17	35	15

IV.a, H_2CO_3.

	n/171	
	A	B
Pea	8	9

V.a, $CuSO_4$.

	n/2048		*n*/4096		*n*/8192		*n*/16484	
	A	B	A	B	A	B	A	B
Pea	2	0	4	3	4	7	28	17
Lupine	7	0	5	6	10	3	13	14
Corn	2	0	16	5	23	10	3	4

VI.a, KOH.

	$n/32$ A	$n/32$ B	$n/64$ A	$n/64$ B	$n/128$ A	$n/128$ B
Pea	0	0	3	0	10	12
Lupine	0	0	4	0	11	5
Corn	0	0	12	10		

VII.a, NaOH.

	$n/32$ A	$n/32$ B	$n/64$ A	$n/64$ B	$n/128$ A	$n/128$ B
Pea	0	0	1	0	18	16
Lupine	0	0	0	0	6	4
Corn	0	0	11	10	17	11

VIII.a, Na_2CO_3.

	$n/8$ A	$n/8$ B	$n/16$ A	$n/16$ B	$n/32$ A	$n/32$ B
Pea	0	0	0	0	8	5
Lupine	0	0	2	0	9	7
Corn	0	0	5	0	28	11

IX.a, $NaHCO_3$.

	$n/4$ A	$n/4$ B	$n/8$ A	$n/8$ B	$n/16$ A	$n/16$ B
Pea	0	0	0	0	8	9
Lupine	0	0	3	0	6	7
Corn	0	0	15	11	2	2

A comparison of data taken from Tables II–IX (those in which radicles were immersed in liquid) with those taken from Tables IIa–IXa (those where radicles were immersed in sand and liquid) may help towards a clearer notion of the action produced by a non-chemical body. In making comparisons, the actual mass of solution used was arranged so as to have, as nearly as possible, the same in each case, with a view towards eliminating every element of inequality excepting the one under consideration. It proved, however, that a difference in quantity, ranging from $3\frac{1}{2}^{cc}$ to 6^{cc}, of actual liquid used, when mixed with sand, produced no noticeable difference in action upon the radicles.

In solutions of HCl and H_2SO_4, $n/512$, all seedlings mentioned, live with at least 3^{cc} of liquid, when sand is present; but in liquid alone, similar seedlings, under similar circumstances, can scarcely endure a concentration of $n/2048$, or in a ratio of 4 : 1. This shows that the actual physical effect of the sand was equivalent to a neutralizing reaction of $9/2048^{cc}$ normal acid in 1^{cc} of solution, because the seedling lived in a solution $3/512^{cc}$, or $12/2048$ of normal acid to 1^{cc} of solu-

tion. When in liquid alone, radicles withstand barely 3^{cc} of $n/2048$* solution, or $3/2048^{cc}$ per 1^{cc} of normal acid; therefore 9/2048 represents the physical effect of the sand with the two substances used. This is about 4:1, at or near the limit where root tips just resist the acid and live.

Similarly for KOH and NaOH, with the pea and the lupine, the sand retards the action of 3/256 of 1^{cc} of normal KOH near the resisting limit. For KOH and corn it is 3/128 of 1^{cc} normal.

The seedlings withstood relatively a very great concentration of $CuSO_4$ when sand was present; actually $n/4096$ (Table Va) as against not less than $n/32768$ without sand. This seems to be due again to the presence of the non-chemical body. The reason why the toxic action is so much reduced with this substance is probably because, as has already been mentioned, the attractive force of the sand is constant, and requires satisfaction; therefore, in dilute solutions, where there is so much less of the solute per unit of volume, the seedling would be relieved of a large proportion of the harmful element. The actual amount for this solute would be $3/4096 - 3/32768 = 21/32768$ gram-ions of copper. This hindrance to toxic effect of the solute is probably also due in some measure to the retarding effect upon diffusion caused by the presence of the foreign body.

The suggestion which arises from this non-chemical action of sand, is that soils may hold mechanically a portion of a solute, and may never give it up. It may be forced to liberate a part of it by the application of another solute which might, in part, satisfy the attractive force exerted by the particles of soil. This may also account for the fact that a chemical analysis is not always a final argument as to the fertility of soil. For instance, suppose KNO_3 were applied in a certain quantity to a pure sand, and plants be allowed to grow for a time in this, it would be found that the plants had been unable to extract all the KNO_3; but if another substance, say $Ca(NO_3)_2$, be then applied, the amount of KNO_3 available might be increased, though no chemical action take place. It is probably thus with the whole subject of fertilizers. A substance may often liberate an important element by taking its place mechanically in the soil, though the substance which had been applied have itself no fertilizing value. The writer is aware that many consider a chemical analysis of soil a definite basis for a liquid nutrient solution, and *vice versa*. Cameron. (Bul. 22, U. S. Dep. Ag., p. 15), quoting Johnson, states: "The analysis of the well water shows that a nutritive solution need not contain

* Slight exceptions to this may be noticed as shown in Table II, but calculations are made only from the most certain limits.

the food of plants in greater proportion than occurs in the aqueous extract of ordinary soil." This is probably the reverse of the actual condition, because, as has already been pointed out, the soil particles have a physical attraction to be satisfied.

The question of selective power of plants is a vague one. It is probably more a name than a fact. The soil selects as well as the plant.

So far as this physiological problem is concerned, it seems that the theory of electrolytic dissociation is insufficient. Certainly no support to the theory comes from the physiological side. Acetic acid, sodic carbonate, sodic bicarbonate and carbonic acid exhibit phenomena quite in opposition to it. Conclusions have been published which, from the data, seem to be entirely unwarranted. Cameron virtually points this out, saying: "The necessity of such assumption would seem to absolutely invalidate the use of such organisms and criteria for the testing of the dissociation hypothesis in any quantitative way." On the other hand, in Jones' 'Theory of Electrical Dissociation,' p. 272, is stated: "The theory of electrolytic dissociation has thus thrown light upon the physiological action of different substances, and the theory has itself been strengthened by these experiments upon living things." Now the experiments recorded in this paper show that the theory throws no light upon such physiological problems, rather the reverse, if anything. A further quotation will show that Jones did not examine the matter as carefully as might be expected, in consideration of the fact that he was compiling a text-book. He states, p. 271, referring to the work done by Heald: The Cu ion is about as toxic as the hydrogen ion," and on page 270: "In the case of strong acids the root would just live in a solution which contained a gram molecular weight of the acid in 6400 liters," and further on: "The roots would just survive in a solution which contained a gram molecular weight of copper ions in 51200 liters." It should be remembered that these quotations from Jones are taken from a recent text-book. A glance at them will convince one that little, if any, care has been taken to present the matter accurately. This is a misinterpretation of Heald for which Heald is in no way responsible.

In the first place, there is no evidence from the physiological side for the theory of electrolytic dissociation, and in the second place, references have been made over and over again to the earlier investigations, with no sure foundation. When these creep into text-books, it is supposed they are considered to be established facts, and, therefore, all the more need to call attention to them.

An illustration may show the mistaken notion following the application of the theory of dissociation to explain certain

physiological phenomena. Heald (l. c., p. 136) states: "Now the carbonic acid in aqueous solutions will dissociate to form H ions and CO_3 ions." This is of course quite probably not correct. He states further, p. 137: "More experiments are necessary to prove conclusively the fact that CO_2 poisoning is due to the effect of the ionic H, and as soon as possible experiments with that view will be carried out." From this latter quotation it is quite clear the author had no experimental evidence in regard to H_2CO_3, yet in the same connection he asserts it as a fact that it dissociates into H ions and CO_3 ions. If the toxic action be due to the H ions,—assuming his prediction of the substance to be warranted—it should be as toxic as H_2SO_4. But it is only about one-fiftieth as toxic as H_2SO_4. This is an illustration of prediction based on the theory of dissociation without basis in fact. The author just referred to is not alone in this respect; and the whole tendency, the whole spirit of the paper, as well as those of some others, seems to *assume the theory of electrolytic dissociation is true, and see if physiological action fits in;* and where it does not, as in acetic acid, *make it fit by assigning function to the whole molecule.*

A cursory glance at the situation might lead one to suppose that the apparent uniformity of toxic action of certain substances, e. g., HCl and H_2SO_4, did show a sort of harmony with dissociation. However, a careful examination of this reveals the fact that it is quite to be expected that these substances would act thus, for the simple reason that they are *chemically equivalent* as a basis of operation. It is not to be wondered at, therefore, that there is such harmony. It could scarcely be otherwise: and so on along the whole line, whether dissociation occurs or not. The only fair conclusion seems to be that the toxic action is a chemical action, because all concentrations made use of are *chemical equivalents.* Jones, p. 268, states: "It had been thought that the physiological action of any substance was due to its chemical nature." Kahlenberg and True, p. 85, state: "It has always been taken as axiomatic that the physiological action of any substance is due to its chemical character." Notwithstanding these statements, from the experiments recorded in this paper, *it should be still so considered.* There seems no doubt whatever that the physiological action is due to the chemical properties of the solute. Though the writers just mentioned do not attempt to explain what the nature of the action may be, they lead one to infer that it is due to some subtle action of a physical nature, involving, it may be, a charge of electricity with which the ion is thought to be loaded.

Dissociation under ordinary circumstances may not take

place at all. The only reliable test to the matter is the conduction of electricity. But this very test may actually *bring about* dissociation, instead of merely showing that it already exists in the solution. Moreover, the theory of the cause of osmotic action does not throw light upon the matter, as notice the results of Morse and Frazer* on sugar solution—a non-electrolyte. They obtain a pressure of about 32 atmospheres, where, according to the theory of dissociation, it ought to be but 22·6. The high vapor densities of certain substances and the lowering of the freezing point of solutions may be explained on other grounds upon which it is not necessary to enter here.

The toxicity of compound ions,—those which are composed of more than one element,—has been discussed by Clark and by Kahlenberg and True, but with diverse results. Clark concluded somewhat generally that a compound ion was *more* toxic than a simple ion. The experiments of Kahlenberg and True lead one to the conclusion that the compound ion is much *less* toxic. They state, referring to such compounds as H_3PO_4, that the acid dissociates into H and H_2PO_4, and the acid H_3PO_4 is equally toxic with HCl. This shows that they consider the H_2PO_4 ion as practically non-toxic, or slightly so. They state further, referring to potassium silver cyanide, that the complex ion Ag $(CN)_2$ is far less poisonous than the Ag ion alone. They say also that ferric ions are much more poisonous than are the complex ions containing ferric iron. Clark, on the other hand, reasoning also apparently from the theory of dissociation, referring to H_2SO_4 states that the ion HSO_4 is 1·3 times as toxic as H, and that the whole molecule (HNO_3) is 7 or 8 times as toxic as the simple ion H.

No attempt is here made to reconcile these statements, for it is impossible to do so. But it shows quite clearly that it is also impossible to reconcile the theory of dissociation with experimental evidence. It shows further, that one can not predict just what will be the physiological result if the basis for prediction be laid upon the theory of dissociation.

Another illustration of the danger in attempting to harmonize the theory of dissociation with physiological phenomena, is furnished by a comparison of toxic action between Na_2SO_4 and NaCl. Cameron places the toxic limit of the former at $3n/400$, and True places that of NaCl at $n/16$.† Now, according to the theory of dissociation (as discussed by Kahlenberg and True), there appears a contradiction; for, since the anion is a negligible quantity in each case, the kation must account for the difference, but the kations are identical. The difference above noted is also too large to be a mere personal difference. Assum-

* Science, ii, 16, 883.

† Cameron gives the limit for NaCl at $n/50$, which is probably correct.

ing Cameron's figures, there is still a wide difference between these two salts with a common kation. But it might be argued that the anion may cause the difference. Let us assume it does. Then, in the case of H_2SO_4 and HCl we have a common kation again, with each of the two anions before mentioned. A comparison of these ought to show H_2SO_4 more toxic than HCl. But all experiments prove rather the reverse. HCl is slightly more toxic (see Tables X, XI, I, II.) Even assuming Kahlenberg and True's own figures for these substances, we find no greater toxic action for H_2SO_4. Considering the comparison between NaCl and Na_2SO_4 we should expect to find it decidedly more toxic.

XX.

		Liquid test.			Liquid and Sand test.
1	2	3	4	5	6
H_2SO_4	pea	2048	$2\frac{1}{2}$	16382	512
"	lupine	2048	5	8192	512
"	corn	1024	1	8192	512
HCl	pea	2048	$2\frac{1}{2}$	16384	512
"	lupine	2048	$2\frac{1}{2}$	16384	512
"	corn	1024	1	8192	512
H_2CO_3	pea	343	20	513	171*
$CuSO_4$	pea	32768	$2\frac{1}{2}$	262144	4096
"	lupine	32768	5	65536	4096
"	corn	131072	1	524288	4096
KOH	pea	256	4	512	128
"	lupine	128	4	256	128
"	corn	64	1	128	64
NaOH	pea	128	3	256	128
"	lupine	64	1	128	128
"	corn	64	$2\frac{1}{2}$	128	64
Na_2CO_3	pea	256	12	512	32
"	lupine	128	8	256	32
"	corn	64	12	256	32
$NaHCO_3$	pea	16	3	128	16
"	lupine	16	20	32	16
"	corn	8	1	16	8

* *n*/171 was the highest concentration we were able to obtain, and both the lupine and the corn withstood this readily in a quantity of 25^{cc} and upwards.

In Table XX is a recapitulation showing the quantities of solution and the concentration which the seedlings just endured. A comparison is also made between the liquid test and the sand test. In columns 3, 5 and 6 is given only the denominator of the fraction whose numerator is *n*. In column 4 is recorded the number of cubic centimeters in which the radicles just lived, and in column 5 is given the highest concentration the seedlings could withstand in a quantity of 25^{cc} or upwards.

It should be remembered always that the test applied to decide life was *further growth* in water after the seedling was taken from the test solution. Column 4 gives the number of cc. in which the radicle just lived at the concentration opposite in column 3. In column 6 is given the concentration the seedlings would endure when sand was present; the amount of solution to each radicle was 3½ to 6^{cc}, and the amount of sand about 5 to 8^{cc}.

A comparison between columns 3 and 5 in Table XX shows the variation due to *quantity* of solution. (It ought to be mentioned that when the experiments were arranged, the liquid used in all the vials of different size was taken from the same preparation, so that practically every element which might affect results was eliminated.) It may be seen further that a comparison of these results with those of Heald shows some difference of figures. No attempt is here made to reconcile these differences because a general *actual* toxic limit is not possible to obtain.

Column 6 shows clearly that the presence of sand affects the characters of the solution in regard to toxicity. In dilute solutions it reduces it enormously; in strong solutions not nearly so much. Though the figures opposite $NaHCO_3$ are close, yet if working with more closely graded quantities and concentrations slightly different results from those given might be expected.

The problem of soils, examined from this point of view, presents a very complicated question, from the fact that several substances enter into the composition of soil water. It is then a problem of permutations and combinations of $(n+1)$ substances, making factorial n cases for each combination. And, since the amount of each may vary from an insignificantly small to a predominating quantity, the number of problems from this side is at once enormous; and if the theory of dissociation be admitted into the proposition, the problem is still more complicated. There is then the possibility of ion effect, coupled with electrical forces, augmented or neutralized by the presence of a number of different ions.

In order to learn something of the differences in effect between fine and coarse sand, solutions of $CuSO_4$, $n/8192$, HCl, $n/512$, H_2SO_4, $n/512$ were compared with the following results: more growth was permitted in fine sand with $CuSO_4$ but, on the other hand, considerably more growth was permitted with coarse sand when HCl and H_2SO_4 were used. In all the experiments these were the general results, H_2SO_4 presenting the most marked character. One explanation of this may be that because of the greater surface, the fine sand would hold mechanically more of the solute when in very dilute solution

with heavy kations; whereas with stronger solutions and lighter kations, the centers of mass attraction being fewer, and the force consequently greater, the result might be that more light kations would be held by a mere force of attraction.

Two forces seem to be exerted, one by virtue of the surface exposed (surface tension so-called), and the other by virtue of the mass (gravitation). When the former encounters a substance which is attracted more by surface tension than it is by the mass, then the fine grains will exert a predominating influence upon the solute. When the latter encounters a substance which is more affected by mass than by surface tension, then the coarse grains will exert a predominating influence. At all events, we have the facts derived from the experiments, and it seems but fair to borrow explanations from the physics side of the question.

In the case of corn seedlings, an aquatic fungus frequently developed if the plants remained in the liquid for a few days. The tendency to curl has also been pointed out.

An investigation into the cause of the fungus growth showed that, near the root tip, some organic substance exuded from the plant. This substance contained some organic matter which acted, on heating, like sugar. When evaporated on a clean cover-glass, a syrup-like substance remained. For a further test, seedlings were allowed to send out aerial roots in a moist chamber under a bell-jar, and the root tips were then cut away at a point about 2^{mm} from the apex. In three hours a drop of clear liquid, about 2^{mm} in diameter, appeared at the cut end of the root. This drop, upon examination, proved to contain a large proportion of organic matter of a sugary nature, and a small quantity of ash of an alkaline reaction.

There is no doubt that this substance forms a nutritive material for fungi. Nor is it confined to the root tip, but may be found 20^{mm} or more from the tip. This was quite apparent in the sand cultures. Upon taking the corn seedlings from the culture media, whether sand or liquid, if the plant had not been killed, the liquid adhering to the tips and elsewhere was of a "glairy" consistency, slightly like white of egg, or like syrup.

The suggestion is here offered that the reason corn is enabled to withstand stronger solutions of acids and bases than some other seedlings, is in consequence of this secretion. Just what function this might serve is not known. At all events, a great loss to the plant, of organic food, may be suffered, if in cultivation the root-ends be bruised or broken.

In regard to the curling of the roots, it may be said that chemotropism has something to do with it, but just why it turns this way or that, in a solution where the forces are equally

distributed on all sides, is not easy to say. Such a curling is often seen in the radicles of corn seedlings grown in water or in the ordinary water-culture media. Cameron (l. c.) gets over the difficulty by saying: "They tended to curl up in an apparent effort to leave the solution, seeking a more congenial environment." This is assigning to plants a will-power we were not aware they possessed.

Summary.

Quantity of solution has an important bearing upon its power to affect the radicle; and rate of diffusion proves also to be of some significance.

Non-chemical* bodies retard very materially the activity of the solute in bringing about death to the radicle. In some instances the toxic effect was reduced 32 times by the mere presence of pure sand. The mere presence of the walls of the glass vessel has a perceptible effect in holding a substance mechanically; and the shape of the vessel is also not without some effect.

The action of the solute upon the radicle is very probably a chemical one.

There is no support to the theory of electrolytic dissociation from the physiological side. In fact, certain substances present phenomena which indicate opposition to it.

Both the carbonate and the bicarbonate, if they dissociate at all, do so in such a manner as to result in a chemical action upon the water, forming a hydroxide as one of the products.

Carbonic acid is of extremely low toxic power, killing the radicle of the pea at $n/342$, but not the corn nor the lupine at any concentration which it was possible to obtain ($n/171$).

Agricultural College, Michigan.

* After this paper was written, an abstract of a paper by True and Oglevee bearing, in part, on a similar line of investigation, appeared in Science Mar. 11, 1904, p. 421.

Art. XLIII.—*Tourmaline from San Diego County, California;* by Douglas B. Sterrett. (With Plate XXIV.)

The tourmaline crystals to be described in this article are from Damaron's Ranch, four miles northwest of Mesa Grande, San Diego County, California. A representative collection of over one hundred and sixty specimens given to Prof. Penfield by Mr. Ernest Schernikow of New York, and deposited in the Brush collection of the Sheffield Scientific School, was used for most of the investigation; which is here directed chiefly toward the study of crystal form. Additional notes were obtained from a brief examination of the collection on exhibition

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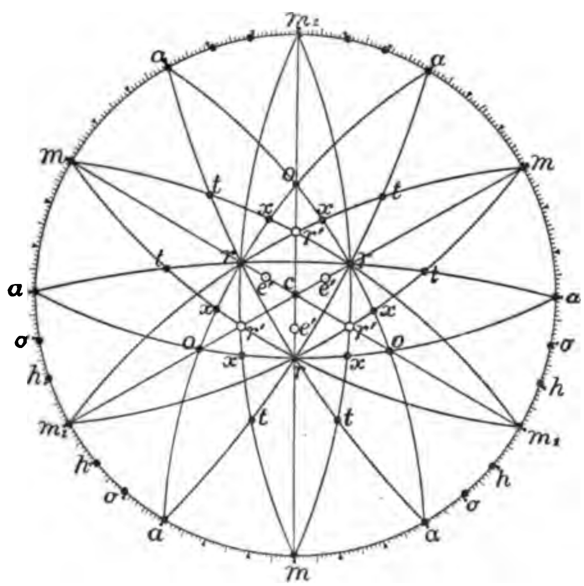


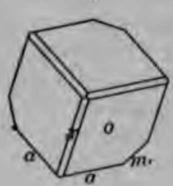
at the Natural History Museum, New York, loaned by Mr. Schernikow, and from the choicest crystals in Mr. Schernikow's possession. The crystals have evidently come from a pegmatite vein, as they are often associated with large quartz and feldspar crystals and bunches of lepidolite mica. They far surpass the crystals of Paris and adjoining localities in Maine in perfection of crystallization, and those of Haddam Neck, both in size and crystallization. It is also probable that no other locality produces stones with more varied and beautiful colors.

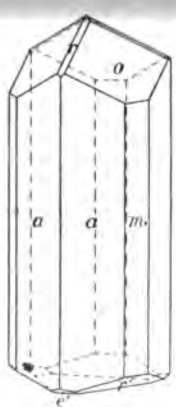
Many crystals are of gem quality, and according to "The Mineral Industry,"* $15,000 worth of gems were produced from this locality during the year 1901, and Mr. Schernikow places the value for 1903 between $40,000 and $50,000.

The number of forms found on the crystals is not great and only those common to tourmaline have been observed, a list of which is given in the accompanying table and shown in stereographic projection in fig. 1.

Prisms.	Upper end.	Lower end.
a $(11\bar{2}0)$	c (0001)	c' $(000\bar{1})$
m $(10\bar{1}0)$	r $(10\bar{1}1)$	r' $(01\bar{1}\bar{1})$
m_1 $(01\bar{1}0)$	o $(02\bar{2}1)$	e' $(10\bar{1}\bar{2})$
σ $(12\bar{3}0)$	t $(21\bar{3}1)$	
h $(14\bar{5}0)$	x $(12\bar{3}2)$	

2





The forms σ and h could not be accurately determined, for the prism faces of the crystal on which they were measured were badly striated. Reflections were obtained from thin glass strips glued on these faces, and gave results approximating to the above symbols. The character of the other crystals measured was such as to permit very satisfactory determinations of the forms enumerated, but it has not seemed necessary to publish a list of the angles measured.

Although owing to the hemimorphic character of tourmaline, the three r faces above form a triangular pyramid and not, strictly speaking, a rhombohedron, it will be convenient to refer to this and similar forms as rhombohedrons, and for like reason to call the t and x faces scalenohedrons.

All of the figures drawn in clinographic projection have the antilogous end up, i. e., that pole which on cooling is positively electrified, and when tested by the Kundt method attracts sulphur. The crystals all follow the general rule, that the end with the steeper forms is the antilogous pole.

For a single locality the crystals show an unusual diversity of habit and color, and in describing them it will be convenient to divide them into types. In the first type the rhombohedron o forms the principal termination above, sometimes with a replacement of its edges by r, as shown in fig. 2. The lower

* Published by the Engineering and Mining Journal of New York.

termination when present is made up of c', r' and e' variously developed. The crystals show considerable variation in length; as a rule they are slender and the prisms are generally striated. No. 2 of the plate has been broken at the lower end and does not show its full length; while No. 3 and fig. 2 represent doubly terminated crystals. The colors are transparent pink or green throughout, or combinations of pink above and green below.

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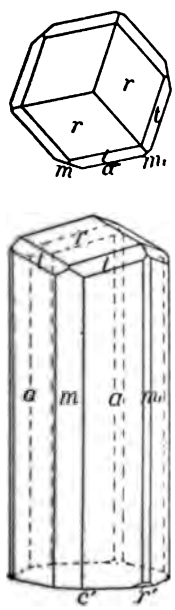

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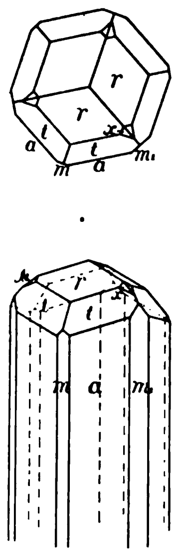

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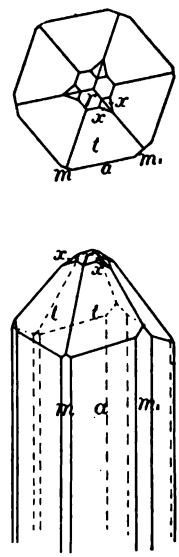


A second type is represented by figs. 3, 4 and 5, which are especially interesting because of the development of the scalenohedron *t*, and on some crystals a second scalenohedron *x* shows slight development. The lower termination when present generally consists of the basal plane and subordinate r', as shown in fig. 3. Most of the crystals are pink or rose color throughout; some are dark enough to be classed as rubellite; occasionally they are light green at the lower end. Some of the finest pink gems are cut from crystals of this type.

It is very unusual to have tourmaline crystals terminated as in fig. 5 by a large development of a scalenohedron. The brown tourmaline from Gouverneur, N. Y., shows a similar develop-

ment, but the scalenohedron is a steeper one, *u* (3251), and fig. 6 is here introduced for comparison.

The features of a third type are the number of prism forms and two bases, generally well developed, with subordinate rhombohedrons *o*, *r'* and *e'*, as shown in fig. 7. The crystals are, as a rule large; 7^{cm} high and 3^{cm} thick not being uncommon. The development of the rhombohedrons *o* and *r'* sometimes varies, with a consequent variation of the base; this forms a connecting link with the first type; for some crystals have only a small base with large *o* faces; if *c* were to fail entirely, the crystal might be considered of the first type.

6

7

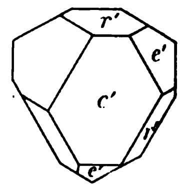
FIG. 6. Brown tourmaline from Gouverneur, N. Y., with scalenohedral development for comparison with fig. 5.

These crystals display a most remarkable variation of color, often of a quality unsurpassed by tourmaline from other localities. As an example, a description of one of the numerous crystals in Mr. Schernikow's collection will answer. Beginning with the lower end there is a layer of fine green; above this, bluish green fading into light rose color; then sea-green passing into smoky brown or brownish green; on this comes a cap of dark pink, appearing scarlet by reflected light. All of these colors, with the exception of the smoky brown, are trans-

parent and clear. One crystal has a lilac-colored band, formed by the blending of pale blue and pink layers.

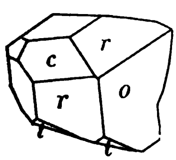
Crystals of a fourth type are often short and stout, terminated by basal planes and rhombohedrons. The prism zone is made up of deeply striated faces; or more properly speaking, layers of small crystals. The terminations consist of the bases and rhombohedrons, *o*, *r*, *r'*, and *e'*. The termination at the antilogous pole more often fails, and is generally rough and much corroded. Fig. 8 is a basal projection of the analogous pole of a distorted crystal of this type. These crystals commonly have a pink or white middle and green layers or cap at the ends. The corroded end is a dark semi-transparent green; while the other is transparent grass- or pale apple-green. One crystal has a cap of pale sulphur-yellow color. Other exceptions are white crystals, faintly tinted with pink and containing perfectly colorless portions.

8



Crystals of a fifth type have a black exterior or shell; generally less than a millimeter thick. Within there is a core of light colored material, green, pink or whitish. When the terminations are present, they are found to be *c*, *o* and *r* above with *c'* and *r'* below.

9



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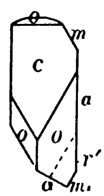

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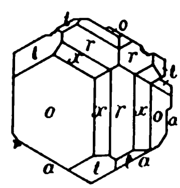
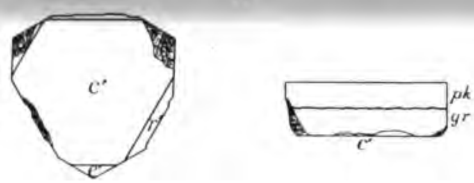


All of the crystals with an olive- or pistache-green color are included in a sixth type. Some are slender, as No. 1 of the plate; these are olive-green passing into brownish green at the upper end. Others vary up to 5^{cm} in thickness and often have a silky luster with pistache-green color. The upper termination of *o* and *r* sometimes appears, though the ends are generally etched and corroded. Crystals of all sizes, from that of a needle up, are found penetrating large crystals of quartz and feldspar.

Figures 9, 10 and 11 are end views of crystals so distorted as to be difficult to put under any special types. In fig. 9 the directions of the prism faces are not preserved on the crystal, so the outline was drawn as nearly as possible like the original.

Fig. 10 is the same as No. 9 of the plate and is a doubly terminated crystal, the dotted line representing the development of one of the lower rhombohedral faces. The crystal shown in fig. 11 was loaned by Mr. Schernikow for examination and is unusual owing to the development of *x* and *t* modified by the presence of an *o* face. One *t* face (on the upper right hand side) is divided into two parts by a deep striation. Fig. 12 is an end and side view of a section cut from the lower end of a pale pink crystal with green cap. A natural basal plane *c′* forms one surface of the section, and is modified by small *r′* and *e′* faces. The intensity and thickness of the two colors are nearly equal and an interesting feature is that on looking through the section in the direction of the vertical axis, the two colors complement one another and a nearly white light is transmitted. Another transverse section with an oil-brown core and rose-colored exterior, each of the finest quality, gives a good illustration of the internal strain crystals may be subjected to, owing undoubtedly to variations in chemical composition; for in most positions under the polariscope, it gives a biaxial interference figure. Some crystals have internal striations parallel to the vertical axis, ending in little pits or etchings on the terminal faces, and when coarse, often partly filled

12



with clay. When these striations are fine and numerous, the crystals may be cut "en cabachon," and give most excellent cat's-eye effects.

In conclusion the writer wishes to express his sincere appreciation of the constant assistance and advice of Prof. S. L. Penfield in the preparation of this article; and also to acknowledge the courtesy extended to him by Mr. Schernikow.

TOURMALINE FROM SAN DIEGO CO., CALIFORNIA.

DESCRIPTION OF PLATE XXIV.*

1. Olive-green crystal of the sixth type.
2. Transparent, sea-green, with clear pink cap ; first type.
3. Crystal with colorless middle part and pale pink ends ; first type.
4. Transparent throughout; lower half pale green, upper half pink ; second type.
5. Pink with cap of exquisite rose color ; second type, same as figure 4.
6. Small pink prism penetrating the end of a quartz crystal.
7. Rough sea-green crystal passing abruptly into a pink cap at the upper end.
8. Distorted and flattened crystal of green color fading into pale pink at the upper end.
9. Distorted crystal shown in basal projection in figure 10 ; sea-green color with an almost colorless cap slightly tinted with pink.
10. Cat's-eye cut from a crystal with internal striations, which can be seen running horizontally through the stone.
11. Section cut from a crystal with a smoky brown core surrounded by a light greenish brown layer and pink shell.
12. Rounded bunch of lepidolite mica with albite adhering to the lower part.
13. Pink crystals coated with a crystalline incrustation of cookeite enclosing quartz and lepidolite.
14. Section broken across a crystal with a dark brown core and lighter colored shell.
15. Bent crystal ; the lower half is light pink passing into a pale green middle and back to pink at the upper end. Where the crystal had evidently been fractured by the bending, it has been healed by bands of fibrous tourmaline with silky luster.
16. A crystal of the fourth type. Grass-green cap at the upper end (analogous pole in this case), with white middle and corroded dirty green cap at the lower end.
17. Group of transparent pale pink crystals; analogous ends free and terminated by c' and subordinate r'.

* Nine-tenths natural size.

ART. XLIV.—*The Limit of Error in the Volumetric Determination of Small Amounts of Gold;* by RALPH N. MAXSON.

[Contributions from the Kent Chemical Laboratory of Yale University—CXXVII.]

IN a former paper from this laboratory, Gooch and Morley* established the accuracy of a method for the determination of small amounts of gold, based upon the reaction

$$AuCl_3 + 3KI = 3KCl + AuI + I_2.$$

Recently the attempt has been made by Rupp† to show that this method is inaccurate, and to bring forward a process based upon the reduction of gold by standard arsenious acid, and titration of the residual arsenious acid by standard iodine. In a study of these two methods,‡ I have verified the results obtained by Gooch and Morley, but have been unable to determine similar amounts of gold with even approximate exactness by the method of Rupp.

More recently,§ Rupp has disclaimed accuracy for his method when applied to amounts less than a few milligrams, and proceeds to discuss the absurdity of attempting to determine volumetrically tenths and hundredths of a milligram of material, however accurate the method may be—and this in the face of his statement, in his own previous paper, of volumetric results carried to thousandths of a milligram.

While quite in agreement with Rupp so far as to admit the absurdity of attempting to determine amounts of material measured in tenths and hundredths of a milligram by means of N/2 arsenious acid, as did Rupp in three out of the six determinations upon which he rested his process, I take the view, that with properly made standard solutions of suitable dilution, it is quite possible for a skillful analyst to determine tenths and hundredths of a milligram of material.

By the use of approximately N/100 iodine and thiosulphate, Gooch and Morley got results with a mean error of 5/100 milligram between extremes of +3/100 mg. and −10/100 mg. in twelve determinations, a single small divided drop of the iodine solution and of the thiosulphate solution being sufficient to produce an immediate reaction with starch, and a bleaching of the starch color, respectively.

When using N/1000 solutions of iodine it was necessary to add to the volume used 0·1$^{cm^3}$ of iodine, in order that the first small drop of gold should bring out the starch reaction. This was a perfectly definite correction and was equivalent to 1/100 mg. of gold.

* This Journal (4), viii, 261, 1899.
† Ber. Dtsch. Chem. Ges., xxxv, 2011.
‡ This Journal (4), xvi, 155, 1903.
§ Ber. Dtsch. Chem. Ges., xxxvi, 3961.

With N/1000 solutions and with the application of this correction, ten experiments gave a mean error of less than 4/1000 mg. between extremes of +2/100 mg. and −29/1000 mg.; while in another series of experiments in which the start was made with pure gold foil, dissolved in chlorine water and treated by a process carefully described, the average error of fourteen determinations was +2/1000 mg. between extremes of +1/100 mg. and −8/1000 mg. This is not theory: it is experiment. Here are volumetric solutions capable of showing 1/100 mg., or less, of gold. Is it any more absurd to determine gold in this manner than to weigh that element upon an assay balance sensitive to 1/100 of a milligram? To be consistent, Rupp should include all processes, gravimetric as well as volumetric, in his sweeping declaration.

The fact that large percentage errors occur in certain determinations made by Gooch and Morley, upon small amounts of gold, is again made the subject of criticism by Rupp.

As I have previously stated, every analytical process has a certain inevitable error, and because of this fact as we approach the limit of accuracy of the process the percentage error will increase rapidly. This increase can, however, under no circumstances be considered a reason why small quantities of substances should be disregarded in analysis, either volumetric or gravimetric. Because the ordinary analytical balance is sensitive only to 1/10 or 1/20 mg. is no reason for declining to weigh tenths or twentieths of a milligram, although the percentage error in weighing such amounts may be very large.

Besides these wholly unreasonable criticisms, reference is made by Rupp to some matters of scientific fact, and to these I next propose to give attention.

To Rupp's statement that with dilute solutions the starch indicator is no longer reliable, it is sufficient to reply that experience has shown that one small drop of N/100 iodine solution developes the starch color at once, in solutions of the volume and concentration described; and if N/1000 solutions be used, a perfectly definite, and not excessive allowance of $0{\cdot}1^{cm^3}$, equivalent only to 1/100 mg. of gold, is all that is needed.

Further, Rupp claims that the decomposition of aurous iodide is the greatest error of the process of Gooch and Morley, and refers to the handbooks of chemistry to substantiate this opinion. No handbooks are known to me which discuss the deportment of aurous iodide under exactly the conditions of this analytical process, but a study of the reaction, of which I made mention in a former paper,* showed that aurous iodide possesses stability sufficient for the purposes of the analytical process.

* Loc. cit.

I have, however, thought the matter of sufficient interest to warrant further investigation concerning the deportment of this salt under more varied conditions.

The method employed to determine the rapidity with which the aurous iodide decomposes was as follows: A measured quantity of a standard gold solution was drawn off into a beaker and diluted to the required volume. To this was added the necessary amount of a solution of pure and specially prepared potassium iodide, starch was added, and the freed iodine immediately treated with N/100 thiosulphate solution, but only to the rose tint, so that, as in the actual analysis, there might be no decomposing action due to an excess of thiosulphate upon the aurous salt.

The time was noted and the mixture allowed to stand until the iodine freed by the decomposition of the aurous iodide had brought the color of the liquid to an ordinary starch blue. The data obtained in this manner are shown in the following table. The gold solution used contained ·00048 g. of metal to the cubic centimeter.

No.	Gold grm.	KI grm.	Volume before the addition of thiosulphate. cm^3	Time in minutes necessary to give blue color.
1	0·0144	0·20	50	19
2	0·0144	0·20	50	47
3	0·0144	0·20	50	95
4	0·0144	0·20	50	150
5	0·0144	0·20	50	115
6	0·0144	0·20	50	82
7	0·0144	0·20	50	50
8	0·0096	0·08	50	17
9	0·0096	0·08	50	95
10	0·0096	0·08	50	28
11	0·0096	0·08	50	78
12	0·0096	0·08	50	18
13	0·0096	0·08	50	30
14	0·0096	0·08	50	36
15	0·0096	0.08	50	32
16	0·0048	0·05	50	45
17	0·0048	0·05	50	168
18	0·0048	0·05	50	25
19	0·0048	0·05	50	48
20	0·0048	0·05	50	43
21	0·0024	0·05	50	95
22	0·0024	0 05	50	105
23	0·0024	0·05	50	135
24	0·0024	0·05	50	none in 3 hours
25	0·0024	0·05	50	none in 3 hours
26	0·0014	0·01	35	130

It may be seen from these results that the decomposition of the aurous iodide under the conditions is comparatively slow, although potassium iodide was present in large excess. In these experiments the coloration ran through various gradations from pink to blue, as the starch used, in common with most specimens, had suffered hydrolytic change, the pink color indicating, of course,* the incipient excess of iodine, and not under-titration as Rupp has stated.

As I have previously shown, a complete determination by the method of Gooch and Morley can be easily accomplished in ten minutes; the maximum time actually necessary for the completion of the titration *after* the formation of the aurous iodide need not exceed four minutes. As can be seen from the experiments tabulated above, the minimum time required for the incipient decomposition of the aurous iodide was seventeen minutes. In no case did decomposition take place immediately, although potassium iodide was present in large excess. It is to be especially noted that these experiments begin where the analytical process ends, so that the probability of any iodine being freed by a too rapid decomposition is rendered yet more remote. The facts, then, afford absolutely no foundation for the statement that the decomposition of aurous iodide is an inherent source of error in the method of Gooch and Morley.

Concerning the accuracy of the method proposed by Rupp it is unnecessary to speak further, since Rupp now disputes the desirability of estimating less than the milligram; but to the reduction of gold chloride by arsenious oxide, the reaction used by Rupp, it is necessary to recur. Rupp states that the process of reduction goes on in acid solution. As I said in a former paper, I have been unable to effect the precipitation of the gold when free acid is present, but after the addition of acid potassium carbonate, reduction takes place. Rupp added to his solution of gold chloride containing hydrochloric acid, 10^{cm^3} of nearly N/2 solution of arsenious oxide. It is to be supposed that this solution of arsenious oxide was made, as usual, by dissolving the oxide in acid potassium carbonate. The question arises as to whether Rupp did not have enough acid carbonate in his arsenic solution to neutralize the free acid. The fact that the gold was precipitated, and within ten or fifteen minutes, points strongly, according to my experience, to an alkaline condition of the solution. So, if to heat a solution of acid potassium carbonate upon the water bath, under the experimental conditions, brings about the formation of an iodine-binding carbonate, and is indeed an error as Rupp says, it would seem that Rupp makes that error. But was it an error? It has seemed worth while to investigate this point.

* See Hale, this Journal (4), xiii, 390, 1902.

A N/10 arsenic solution was prepared as usual with the aid of 20 grams of potassium acid carbonate to the liter. Twenty-two cubic centimeters of this solution were drawn off and titrated with an approximately N/10 iodine solution in the usual manner. Four lots of this arsenic solution of 22^{cm^3} each were then carefully drawn off and heated upon the steam bath for thirty minutes, and when cool were titrated against the above mentioned iodine solution. The volume of the solutions used in these experiments was in all cases approximately 75^{cc}. The results obtained are given in the accompanying table.

Standard As_2O_3 taken. cm^3.	Iodine used to titrate at once. cm^3.	Iodine used to titrate after heating ½ hour on the water bath. cm^3.
22·0	22·08	22·10
22·0	22·07	22·08
22·0	22·08	22·09
22·0	22·07	22·08

These figures show conclusively that acid potassium carbonate in solution of the concentration used in these experiments, 0·44 grms. in a volume of 75^{cc}, does not in thirty minutes heating upon the water bath undergo such change as to cause it to absorb an appreciable amount of iodine in the following titration. Just what the effect may have been in Rupp's experiments cannot of course be determined in the absence of knowledge in regard to the acidity of his gold solution, and the alkalinity of his arsenic solution.

In conclusion it is obvious that the criticisms made by Rupp are not warranted by the facts. While, as its author now concedes, the method proposed by Rupp is not to be considered of value for the determination of small amounts of gold, all the evidence goes to show that the process of Gooch and Morley is accurate, and in the hands of a skillful analyst, adapted to the estimation of minute quantities of gold.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *Hydrates in Solution.* — It has been known for some time that many inorganic salts give abnormal results in the lowering of the freezing points of their comparatively concentrated aqueous solutions. They show in dilute solutions depressions of the freezing point which correspond to their ionization as determined by electrical conductivity, but when a certain degree of concentration has been reached the depression of the freezing point is abnormally great in most cases. H. C. Jones and his co-workers have made an extensive study of this matter, and it has been found that all but nine of the forty-nine substances experimented upon showed a minimum in the freezing-point curve; that is, the effect of the substance in lowering the freezing point gradually diminished as the concentration increased—on account of diminished ionization—and then the abnormal increase of effect occurred to such an extent that the curve showed a minimum point. Even where the freezing-point curves did not show a minimum, there was an abnormal depression of the freezing point in nearly every case with concentrated solutions. It was found also that those substances which crystallize out of solution with the larger number of molecules of water of crystallization give the greatest molecular lowerings of the freezing point of water in concentrated solutions. The boiling-point curves, as far as they have been worked out, also show a minimum, but this occurs at a greater concentration than in the corresponding freezing-point curve.

From the results of this work, the important conclusion is reached that in concentrated solutions a part of the solvent is combined with the dissolved substance, and such solutions are, therefore, more concentrated than they would appear from the amount of dissolved substance present in them. This view explains the abnormal behavior of concentrated solutions in a very simple and satisfactory way; for it is difficult to imagine that substances should crystallize with water of crystallization, unless they were capable of combining with this water while in solution. If further work confirms this new explanation, a serious objection to the ionic theory of solutions will be removed.—(Jones and Getman) *Amer. Chem. Jour.*, xxxi, 303. H. L. W.

2. *A Microscopical Method of Determining Molecular Weights.* —This interesting method, described by George Barger, of King's College, Cambridge, England, depends upon the increase or decrease in size of alternate drops of two solutions in a closed capillary tube. One of the solutions is prepared from a substance of known molecular weight, while the other contains a known amount of the substance whose molecular weight is to be determined. When the two solutions contain the same number of molecules in a given volume, the vapor tensions will be equal and

the drops will not change in size, but if one of the solutions is stronger in this respect, its drops will increase in size at the expense of the other. The method then consists in finding a known solution of the same vapor tension as the known one by microscopic measurement of the drops. It is not necessary that the solvent used should have a constant melting point or a constant boiling point, hence impure solvents, such as ether saturated with water, 90 per cent alcohol or 80 per cent acetic acid can be used successfully. The solvent should not be too volatile, on account of the difficulty of manipulation, and, on the other hand, if the solvent is not sufficiently volatile, the experiment takes too long. The details in regard to the application of the method need not be given here, but it may be observed that the process has been tested with a great variety of substances with satisfactory results.—*Jour. Chem. Soc.*, lxxxv, 286. H. L. W.

3. *Rubidium-Mercuric Double Salts.* — GROSSMANN has prepared the double salts

$$2RbI \cdot HgI_2,$$
$$RbI \cdot HgI_2,$$
$$2RbSCN \cdot Hg(SCN)_2,$$
and $$RbSCN \cdot HgSCN,$$

and also a pyridinium-mercuric cyanide-thiocyanate,

$$(C_5H_6N)SCN \cdot Hg(CN)_2.$$

From these results it appears that rubidium iodide forms a much less extensive series of double salts with mercuric iodide than is the case with cæsium iodide, for with the latter five double salts are known. The double thiocyanates under consideration correspond exactly to the cæsium-mercuric salts described by Wells and Bristol, except that one of the latter, $2CsSCN \cdot Hg(SCN)_2 \cdot H_2O$, contains water; hence there is no evidence in this case of a more extensive series of salts with cæsium than with rubidium. The pyridine compound is an example of the combination of mercuric cyanide with many kinds of salts.—*Berichte*, xxxvii, 1258. H. L. W.

4. *Zirconium Tetra-iodide.* — By acting upon metallic zirconium or upon zirconium carbide with hydrogen iodide at elevated temperatures, STÄHLER and DENK have obtained the tetra-iodide ZrI_4 in the form of a sublimate, consisting of a reddish brown, crystalline powder which fumes strongly in the air and reacts violently with water and acids. This substance is entirely different from the product, supposed to be this compound, obtained by Dennis and Spencer several years ago, which consisted of white crystals that were not decomposed by water or dilute acids. It appears, from the close analogy known to exist between the compounds of titanium and zirconium, that the composition of the white compound was incorrectly determined.—*Berichte*, xxxvii, 1135. H. L. W.

5. *Use of the Thermal Junction in the Ultra-Violet.* — A. PFLÜGER shows that it is possible to detect the heat of spectral lines in the extreme ultra-violet by means of a Ruben's thermal junction and the throw of a delicate galvanometer. The strong lines of cadmium, zinc, aluminium, etc., gave deflections of many hundred scale divisions, and even the finer lines of these metals gave deflections from 20 to 100 scale divisions.

It is shown that the energy distribution in these ultra-violet lines of the metals, with the exception of magnesium and iron, is strongest below wave length $260\mu\mu$, and in a region where the ordinary photographic plate fails to register. The aluminium line at $186\mu\mu$ shows a very strong energy radiation. The author found it useful to use single breaks of the primary circuit and to notice the first deflection of the galvanometer. The thermal junction was enclosed in a vacuum to avoid currents of air. The table of distribution of energy in the spark spectra of metals shows that the energy of radiation of the ultra-violet lines is in general far greater than the ultra-red lines. At first a quartz spectrograph was used, later a Rowland grating ruled on a fluor spar plate. Schumann's very short wave lengths also gave deflections with the thermal junction.—*Ann. der Physik*, No. 5, 1904, pp. 890–918. J. T.

6. *Internal Friction of Nitrogen.*—It is proved in the molecular theory of gases that the internal friction is independent of the density. Prof. S. W. HOLMAN has shown that the dependence of the viscosity upon temperature cannot be represented by a function of the absolute temperature with constant exponent, but that it increases the more slowly with the temperature the higher this latter is. In order to retain the theory of elastic spheres, STEFAN imagines that the mean free wave lengths at equal pressures increase with the temperature and the size of the molecule at the same time diminishes. One cannot at present verify this hypothesis by calculation. SUTHERLAND supposes a change in the attraction between the molecules is modified by a rate of collision, and he arrived at a formula which expressed under this hypothesis the ratio of the frictional coefficients at any two temperatures. A. BESTELMEYER takes up the measurement of the internal friction of nitrogen, according to the method used by Holman and arrives at the result that Sunderland's formula represents with great approximation the internal friction of nitrogen between 300° and −190°. The departure from the law at the temperature of liquid air indicates the beginning of a greater friction at lower temperatures.—*Ann. der Physik*, No. 5, 1904, pp. 944–995.

J. T.

7. *Damping of Electrical Oscillations.* — The resistance of the electric spark assumes considerable importance in the subject of wireless telegraphy. The resistance is variously extended by different observers. BJERKNES estimates it at 11 ohms. BRAUN as 0·1 ohm. K. SIMONS measures the amplitude of electrical waves damped by spark gaps of increasing lengths, and concludes

that the resistance of a spark gap is so much the smaller, the greater the quantity of electricity in the discharge, and that within the limits of his observation the resistance of the spark gap increased with the length.—*Ann. der Physik*, No. 5, 1904, pp. 1044–1053. J. T.

8. *On the Compressibility of Solids*;* by J. Y. BUCHANAN, F.R.S.—The author has carried on a series of careful experiments for the determination of the absolute linear compressibilities, from pressures of 200–300 atmospheres, and at temperatures between 7 and 11° Centigrade, of the metals platinum, gold, copper, aluminium and magnesium. Tne method employed is that used by the author in determining the compressibility of glass in 1880, and developed earlier in connection with the deep-sea soundings made by the Challenger Expedition in 1875. Briefly stated, this method consisted in the use of a solid piezometer in which the rod of the glass to be experimented upon (57^{cms} in length) was inserted in a closely fitting tube of the same material; the two were fused at one end and at the other there was an empty space of some 3^{cms} between the end of the rod and that of the tube; a steel thermometer index was inserted at the end of the rod and the tube then sealed.

"Before the instrument was attached to the sounding line, the index was brought down by means of a magnet to rest on the end of the internal glass wire, exactly in the same way as if it had been the mercury column in a *maximum* and *minimum* thermometer. The instrument was then sent to the bottom, or to whatever depth might be decided on. During the descent the temperature of the glass, both inside and outside, fell with that of the water through which it passed, but as the contraction produced was the same on the wire and on the tube, there was no differential effect to be recorded by the index. On the other hand, the increasing pressure, as the instrument descended, affected only the outside tube, which it shortened. In contracting, it was obliged to pass the index, which was kept in its place by the internal wire. When the instrument was being hove up, the reverse process took place; the tube lengthened, and lifted the index clear of the internal wire by an amount equal to the lengthening of that portion of the tube. As the whole clearance produced by the expansion from the greatest depth did not exceed 1mm., its amount had to be estimated by the eye with the assistance of a magnifying glass."

The instrument of precision constructed in 1880 on the basis of the Challenger observations was essentially the same as that employed in the present research. The various parts of the latter instrument were made, however, of steel. The metals experimented upon were in the form of rods or wires and fitted into steel tubes passing into a central steel block. The ends of the rod or wire were closed with thick glass tubes kept in their places by open

*Read before the Royal Society of London, Feb. 25, 1904; from an advanced proof sent by the author.

steel caps; each tube was observed by a microscope with micrometer eye-piece. Details in regard to arrangements of the parts, the manometer employed, etc., will be found in the original paper. In regard to the progress of an experiment the author remarks:

"The effect observed and measured is the lengthening of the rod when the pressure is relieved. As the compressibility of solids is very small the highest pressures have been used which were found to be compatible with the reasonable persistence of the glass terminals; the usual pressure was in the neighbourhood of 200 atmospheres. Very few of the glass terminals stood over 300 atmospheres. The pressures actually chosen were as nearly as possible those at which the manometer had been compared with the 'Challenger' piezometer. The body under observation is in the form either of a rod or a wire. If it is in the form of a rod then it is fitted with wire ends of sufficiently small calibre to enable them to enter the glass terminals. During an experiment with a rod it contracts while the pressure is being raised, and expands again when the pressure is relieved. The steel tube which holds it, however, acts in the opposite sense: it expands while the pressure rises and contracts while it falls. If the two surfaces were perfectly smooth, one half of the change of length would be measured at the one end and the other half at the other end. As the surfaces are not perfectly smooth, this does not usually occur. Moreover the steel tubes are prolongations of the central steel block which holds them. The block is bored with holes at right angles to each other in the three principal directions. Consequently for a distance of about an inch and a half in passing through the block the rod is not supported at all. With the exception of this small portion, however, the rod is supported throughout the whole of its length by the steel tube. Now, although it is thus nominally supported equally throughout the whole of its length, we know that in reality this is pretty certain not to be the case. At some place, either in the right arm or in the left arm of the apparatus, the rod is sure to bear more heavily than in any other part. The contraction under pressure and the expansion under relief of pressure will then apparently take place as from this point as origin. Supposing this point itself to be motionless it is evident that the change of length measured at the two ends will be in the same proportion to each other as would be the arcs which they would describe if the rod were a lever oscillating on the point as a fulcrum. As there is no support at all at the centre this point must lie on one side or on the other of it and the motions of the ends must be unequal. But the fixed point of the tubular receiver is the central block; therefore any point in, let us say, the right-hand tube will, when pressure is being raised, move to the right, and on relief of pressure, retreat by an equal amount to the left. Consequently when we observe and measure the change of position of, for instance, the right-hand extremity

of the rod, when the pressure is relieved, that change of position is composed of two motions, the expansion of the part of the rod which lies between the right-hand extremity and the point in it whose motion with respect to the steel carrying tube is nil, along with the proper motion of that point. Similarly, when we measure the change of position of the left-hand end, it also is composed of two parts, the expansion of the part of the rod which lies between the left-hand extremity and the same point in the length of the rod where its motion with respect to the steel tube is nil, along with the proper motion of that point. But at the left-hand end the motion of expansion is to the left, and at the right-hand end it is to the right, while the proper motion of the position of the common point on the rod and on the tube is always in one direction, and in this case, to the left. Therefore the distance measured in the right-hand microscope is the expansion of the portion of the rod which lies to the right of the point on it which is motionless relatively to the tube *minus* the proper motion of this point: and the distance measured at the left-hand end is the expansion of the remainder of the rod *plus* the proper motion of the common point. Consequently the algebraic sum of the two motions measured is the expansion of the rod under the relief of pressure."

The following table gives a summary of the results obtained which are stated in full in six tables preceding. This final table is as follows:

Substance.	Year.	Atomic weight.	Density.	Compressibility.	
				Linear.	Cubic.
Platinum	1904	194	21·5	0·1835	0·5505
Gold	"	197	19·3	0·260	0·780
Copper	"	63	8·9	0·288	0·864
Aluminium	"	27	2·6	0·558	0·1674
Magnesium	"	24	1·75	1·054	3·162
Mercury	1875	200	13·6	1·33	3·99
Glass, flint	1880	...	...	0·973	2·92
" "	1904	...	2·968	1·02	3·06
" German ..	"	...	2·494	0·846	2·54

"In this summary the compressibilities of English flint glass and of the glass of which ordinary German tubing is made as well as that of mercury have been included for purposes of comparison. The compressibility of mercury rests upon a large number of observations made in the 'Challenger,' by which its apparent cubic compressibility was found to be 1·5 per million per atmosphere."

The author calls attention to the relation existing between compressibility and density, and remarks that a field for interesting research is here opened in which the method is capable of great refinement.

II. Geology and Natural History.

1. *United States Geological Survey.*—The following publications have been recently issued :

Folio No. 102. Indiana Folio, Pennsylvania ; by George B. Richardson. The Indiana quadrangle is made up of Carboniferous strata nearly all belonging to the Pennsylvanian series and containing workable beds of coal (Freeport). The two characteristic plains of the Allegheny Plateaus are almost unrecognizable in this part of Pennsylvania. The geologist will note the omission of structure sections.

No. 103. Nampa Folio, Idaho-Oregon ; by Waldemar Lindgren and N. F. Drake. The geological map of the Nampa quadrangle shows wide areas of dissected Tertiary lake beds together with extensive Quaternary gravels and recent flood plains. Tertiary basalt and rhyolite and Quaternary basalt occupy smaller areas. The lake beds of the Payette and Idaho formations once covered the whole district and this folio is in particular a study of the geographical conditions during the formation and partial destruction of beds of sand, gravel and clay with a thickness of 200 to 1000 feet. The characteristics of stream beds in arid regions are well shown by the Payette, Boise and Snake rivers.

No. 104. Silver City Folio, Idaho ; by Waldemar Lindgren and N. F. Drake. With the exception of Cretaceous? granite, the formations represented on the Silver City quadrangle are Eocene, Pliocene and Quaternary. An early Tertiary epoch of erosion was followed by outbursts of rhyolite and basalt and the deposition of the Payette lake beds to a thickness of 2000 feet. A short period of erosion enabled the streams to cut to their present levels. The Idaho formation was deposited in the waters of a shallow lake during Pliocene time. The Snake River Canyon was cut during Miocene. Glassy basalts form the highest Tertiary beds and may have extended into the Quaternary. Terraces show the gradually deepening channel of the Snake River. The ore deposits at Silver City are fissure veins of post-Eocene age and cut through granite, rhyolite and basalt. Opals occur in vesicular cavities in the rhyolite and basalts.

No. 105. Patoka Folio, Indiana-Illinois ; by Myron L. Fuller and Frederick G. Clapp. Carboniferous strata of the Pennsylvanian series containing minor veins of coal are exposed in a small portion of the Patoka quadrangle. The most prominent and widespread formations are the glacial drift and the Wabash flood plains. The Illinoian stage is represented by an extensive series of lake deposits, gravel plains and ridges, and till sheets. The Iowan stage is represented by marl loess, while of the Wisconsin stage there remain small areas of dunes and terraces. The mineral resources of this region are coals and clays. Much valuable land has been reclaimed by draining and diking.

Bulletin No. 225. Contributions to Economic Geology, 1903.

S. F. EMMONS, C. W. HAYES, Geologists in charge. 527 pp. This report contains a series of fifty-one contributions from thirty-seven members of the Survey who have been engaged chiefly in economic work during the year. Brief introductory statements are also given on the investigation of metalliferous ores by S. F. Emmons and of non-metalliferous economic minerals by C. W. Hayes.

2. *The Atoll of Funafuti. Borings into a Coral Reef and the Results.* xiv+428 pp., 6 pls., 69 figs. with 21 charts and geological maps. Published by the Royal Society.—Darwin believed that the history and origin of coral reefs must remain uncertain until a drill core could be obtained for a depth of at least 600 feet. Under the lead of Professor SOLLAS the Royal Society undertook to carry out this suggestion, and a committee, with Professor T. G. Bonney as chairman, was appointed to have general supervision of the project. Few scientific expeditions can match the Funafuti undertaking in determination and thoroughness. In 1896 Professor Sollas failed to attain a greater depth than 105 feet. The expedition of that year resulted, however, in valuable collections and in the construction of the most accurate and detailed chart yet made of an atoll. A study of the surface features and of the changes in elevation was made but few conclusions of general application were reached. Meteorological observations and magnetic surveys were also made. The expedition of 1897 resulted in a drill hole 698 feet deep, but was unsatisfactory owing to the small amount of solid core obtained. A detailed geological survey was, however, made of the atoll by Professor DAVID and Mr. SWEET. The third expedition, in 1898, succeeded in driving the boring down to 1114½ feet and obtaining about 384 feet of solid core. A hole was also bored into the lagoon to a depth of 245 feet. Slices for microscopic examination were taken longitudinally from the middle of each piece of rock. The core proved that the atoll was formed from the surface to the bottom of the bore of calcareous rock, chiefly composed of *Lithothamnion* and *Halimeda* as well as of reef-building corals. The lower part of the core seemed like a consolidated chalky ooze but was determined to be coral material converted into dolomite. A collection of living organisms on the seaward slope of the lagoon down to 200 fathoms was made for comparison with the dead organisms of the core rock. Professor David finds that the original foundation of the atoll is probably volcanic, that its shape has been modified by organic growth, winds and currents, that it is slowly enlarging its periphery, and that several oscillatory vertical movements of the shore have taken place in the immediate past. The Biology of the Reef-forming Organisms is discussed by A. E. FINCKH (pp. 125–150). Arranged in order of importance, Mr. Finckh describes the distribution, mode of occurrence, etc., of *Lithothamnion*, *Halimeda*, *Foraminifera*, *Corals*. Observations on the growth of reef-building organisms showed interesting results. For instance,

a mass of Halimeda increased 2¼ inches in height and 3¼ inches in thickness in six weeks! The drill cores were sent from Funafuti to England and were examined in microscopic sections by Professor JUDD and Dr. HINDE (pp. 167–361). The quantity of calcareous algæ is surprisingly large. Oolitic structure and stratification are absent and there is no admixture of deep water organisms, the same genera and species occur from top to bottom of the section. Extensive chemical and mineralogical changes have taken place in the rock since the corals were living, and these changes have been studied in detail by Professor Judd and Dr. CULLIS.

The reviewer is disappointed to find no discussion of the origin of coral reefs as illustrated by this typical atoll, yet the conclusion seems unavoidable that subsidence has been the chief cause of growth of the reef in this case. The workers in the Funafuti project deserve high praise for the conception of the scheme, for its successful execution under discouraging circumstances, and for the valuable scientific results obtained.

3. *A Revision of the Paleozoic Bryozoa;* by E. O. ULRICH and R. S. BASSLER. *Part 1. On the Genera and Species of Ctenostomata.* Reprinted from the Smithsonian Collections (Quarterly Issue) vol. 45, published April 11, 1904.—In this first part of the much needed revision of the Paleozoic Bryozoa, the authors discuss all the known species which can be referred to the order Ctenostomata. While the rather peculiar fossils so classified can not be proved to belong to this order, most of whose members are living species, the evidence seems to point strongly in that direction. The greatest objection is that the zoaria of the recent species are horny or membranaceous, while those of the Paleozoic forms were sufficiently calcareous to be preserved. The species, which number thirty-three, are arranged under five genera and three families: the Rhopalonariidæ (*Rhopalonaria*), the Vinellidæ, new family, (*Vinella*, *Heteronema*, gen. nov. *Allonema* gen. nov,), and the Ascodictyonidæ (*Ascodictyon*). It will be noticed that the family Ascodictyonidæ is here restricted to the typical genus and *Vinella* removed to a new family erected to include it and its allies. It is to be regretted that the authors have seen fit to insert here descriptions of a new genus and two new species, *Heteronema? contextum* sp. nov. and *Ptychocladia agellus* gen. et sp. nov. which are of so problematical a nature that they admit that the one may be a sponge and the other an alga or some peculiar type of Foraminifera. While there is reason for publishing descriptions of such peculiar organisms in order to get the opinion of other writers on the subject, it does not seem desirable to give new names, particularly new generic names, to fossils whose characters are so obscure that they cannot be definitely referred to any class or even kingdom. It is better to await the discovery of good material, as publication at this time only invites further revision. In addition to the description of the species, the paper

gives a good summary of the literature, and is well illustrated by four plates containing many figures of recent and Paleozoic Ctenostomata. P. E. R.

4. *An attempt to Classify Paleozoic Batrachian Footprints.* Trans. Roy. Soc. Can., 2d ser. vol. ix, Sec. IV, p. 109, 1903. *New Genera of Batrachian Footprints of the Carboniferous System in Eastern Canada.* Can. Rec. Sci., vol. ix, No. 2, p. 99, 1903; by G. F. MATTHEW, LL.D.—These articles are complementary to each other. The first takes a wider field of view than the second, viz.: the described Carboniferous tracks of America, supposed to have been made by Batrachian animals, and is an endeavor to classify these footprints according to their forms, and the number of toes represented. The author does not think the presence or absence of a tail mark or central groove between the rows of footmarks of the right and left limbs of general classificatory value, as some tracks which are closely alike in other respects are distinguished mostly by this marking; and the "tail mark" may be absent from one part of a trail and present in another.

A table is given at page 111 of the first paper in which the tracks of the Lower Carboniferous and the Coal Measures are arranged according to the number and the weight of the toe-impressions, etc.

Plates show some of these characteristic tracks, and give figures of new genera proposed. It is stated that no European footprints of Carboniferous age were considered in this classification and description of American forms.

5. *Geology;* by THOMAS C. CHAMBERLIN and ROLLIN D. SALISBURY. In two volumes. Vol. I, Geologic Processes and their Results. xix and 654 pp., 24 pls., with three tables of water analyses. New York, 1904 (Henry Holt & Company). — This volume, printed in clear type upon a heavy grade of paper, illustrated by numerous original drawings and photographs, both well selected and reproduced, possesses a distinctive character and fills a place not quite occupied by any other manual. The methods of treatment, as stated in the preface, bring especially to the front the methods of action and developmental aspects of the geologic agencies. Careful distinctions are drawn between those principles well founded on observed facts and others which have usually been as commonly accepted but which ultimately depend upon hypotheses as to the origin or internal nature of the earth. In the less certain departments of geological knowledge the method of multiple or alternative hypotheses is developed and the student shown the limitations of present real knowledge upon the subject. The first chapter consists of a preliminary outline on the field of geology, following which are chapters upon the work of the atmosphere, of surface and underground water, of snow and ice, structural geology, movements and deformations of the earth's body, extrusive processes and the geologic functions of life. The reputation of the authors in their several specialties is a sufficient

guarantee as to the depth and thoroughness of treatment, while in the chapter on the "Origin and Descent of Rocks," in which is presented an outline of the recently proposed quantitative system of classification, the authors have had the assistance of Prof. J. P. Iddings.

In the reviewer's opinion, the volume hardly supplants the manuals at present in use but rather supplements them, and from the somewhat philosophic and evolutionary cast would be most profitable to the student who has previously accumulated sufficient facts to feel the need of their coördination. It will be of chief value, therefore, to advanced students, to geological specialists, enabling them to get comprehensive outlooks over related fields, and to teachers of geology in general. The character of the volume should make it attractive also to the general reader of scientific tastes who wishes to follow the latest trends of geologic thought. J. B.

6. *The Mineral Resources of the United States for the Calendar year 1902;* DAVID T. DAY, Chief of Division of Mining and Mineral Resources. Pp. 1038, 8vo. U. S. Geological Survey, Washington.—This is the Nineteenth Annual Report of the series, and is in the octavo form which is most convenient for use. It gives the usual summary of the mineral production for the year, with detailed papers on specific subjects by different authors. The system now adopted of distributing the individual chapters in advance of the final volume, whenever such are ready, has the great advantage of bringing the material within reach of the public very promptly, while the complete volume issued later is invaluable for reference.

7. *Fragmenta Florae Philippinae;* by J. PERKINS, Ph.D. Fascic. 1; 66 pages imp. 8vo, Leipzig, 1904 (Gebrüder Borntraeger, price 4 marks).—Even before the pacification of the Philippines various projects were formed by Americans for the scientific investigation of the Islands. It was felt that the American occupation of this biologically rich archipelago not only offered to our investigators new opportunities but in a way imposed upon them certain obligations toward activity in the fresh field thus unexpectedly opened. In their enthusiasm some of those most eager to undertake this task little appreciated its difficulty. Biological areas are not changed by shifting political boundaries. The Philippines are and must always remain a part of the Old World. We have not in all America adequate literature or authentic specimens for a scholarly examination of the Philippine flora. To accumulate such material must be a matter of years of patient and critical labor. It is true that American energy, backed by the liberal support of the United States government, as well as by private patrons of science, could speedily bring together in our country Philippine collections more extensive than any which have resulted from the slower methods of Spanish or other foreign explorers, yet this is by no means sufficient. The Philippine flora possesses such a strong affinity with

the vegetation of the other Australasian islands, and, indeed, with that of continental India, that it can be studied intelligently only through comparison with types in foreign herbaria and by investigators familiar with Old World floras.

Under these circumstances, it was a wise decision of the Carnegie Institution to make a grant, not for the investigation of the Philippine flora in America, but to aid Dr. Janet Perkins in studying the subject in Berlin, where with access to numerous Old World types and with the counsel and collaboration of highly trained specialists on the Asiatic and Australasian floras, the work could be carried on in a far more scholarly manner. It is accordingly with great regret that we learn that this grant of the Carnegie Institution has not been renewed after the first year. Dr. Perkins, however, has continued her examination of the Philippine flora and a substantial installment of the results is now at hand.

The body of the present paper is occupied by an "Enumeration of some of the recently collected plants of Ahern, Jagor, Lober, Merrill, Warburg and others." In this copiously annotated list, including many diagnoses of new species and much critical synonymy, the *Leguminosae*, *Dipterocarpaceae*, *Anacardiaceae*, *Meliaceae*, *Pinaceae*, and *Taxaceae* have been treated by Miss Perkins herself, the *Symplocaceae* by Brand, *Acanthaceae* by Lindau, *Fagaceae* by von Seemen, *Typhaceae* by Graebner, *Orchidaceae* by Schlechter, *Palmae* by Beccari, *Myristicaceae*, *Pandanaceae*, and *Begoniaceae* by Warburg, and *Sapindaceae* by Radlkofer,—names which amply attest the critical nature of the work.

In a paper of such composite authorship uniformity can scarcely be expected, yet it is to be regretted that the diagnoses are partly in Latin and partly in English, and that the arrangement of the families is quite arbitrary, which in a publication as yet unindexed gives needless difficulty of reference. Among the plants discussed those of Mr. E. D. Merrill and of Dr. O. Warburg are the most numerous and interesting. It is to be hoped that Dr. Perkins may receive the encouragement and facilities in the continuance of her work which its scientific value so richly merits.

B. L. R.

8. *Botanical Publications by the Bureau of Government Laboratories at Manila.*—A series of pamphlets are being issued from time to time, under the auspices of the Department of the Interior, from the Government Laboratories in Manila, of which Mr. Paul C. Freer is Superintendent. Among these we note Nos. 6, 7 and 8, recently distributed, upon botanical subjects. No. 6 (36 pp.), by Elmer D. Merrill, describes new and noteworthy Philippine plants, and also discusses the American element in the Philippine flora. No. 7 (43 pp.), by Penoyer L. Sherman, Jr., discusses the gutta percha and rubber of the Islands, describing the various species and giving their distribution, with a map and numerous illustrations. Suggestions are made in regard to the

prospect not only of utilizing the natural supply, but also of introducing and cultivating foreign species.

No. 8 (193 pp.), by Elmer D. Merrill, gives a Dictionary of the plant names of the Islands with the botanical equivalents. There are two parts, in the first of which the local names and in the second the botanical names are made the basis of the alphabetical arrangement.

III. Miscellaneous Scientific Intelligence.

1. *Wilhelm Ostwald;* by P. Walden. 8vo, pp. 120. Leipzig, 1904 (W. Engelmann, price 4 marks).—Last December the friends and former students of Wilhelm Ostwald celebrated in Leipsic the twenty-fifth year of his doctorate. A special volume of the Zeitschrift für physikalische Chemie was issued on the occasion, and an account of Ostwald's life and work up to the present time. The volume of the Zeitschrift, containing nearly nine hundred pages, consists of contributions in German, English, and French from over thirty of his former students, coming from eight different countries.

Walden's account of Ostwald's life and work is exceedingly interesting and is told in a most entertaining manner. He was well qualified to undertake the work as he studied with Ostwald and is professor at Riga, where Ostwald was born and where he was professor for six years.

Ostwald was born in 1853, and as a boy and when first a student at Dorpat he was not particularly forward in his studies. When once started on his profession, however, his progress was extraordinary. After taking his doctor's degree in December, 1878, he immediately became an instructor in Dorpat. Two years later, in 1881, he was called to Riga as professor of chemistry, where he remained till 1887, and here in 1886 he received his first foreign student, S. Arrhenius, who proposed the theory of electrolytic dissociation the following year. He became professor of physical chemistry in Leipsic in 1887, a position which he still holds.

The first volume of his great 'Lehrbuch der allgemeinen Chemie' appeared in 1885 and from that time forward his literary work has been prodigious. He has written over twenty volumes representing fifteen thousand pages, besides several thousand reviews of scientific investigations and books. The Zeitschrift was started chiefly by him in 1887 and he has been one of the editors ever since.

As a teacher, he has been remarkably successful. His laboratory at Leipsic has been the center for physical chemistry since he took charge, and almost every branch of the subject has received its share of attention. Students have come to him from every civilized country. At the same time, he has carried on many investigations of his own. H. W. F.

2. *Changes in the Transparency of the Earth's Atmosphere.*—A circular letter has been issued, under the auspices of the U. S. Weather Bureau, having as its object the accumulation of data bearing upon the general diminution in the transparency of the earth's atmosphere noted by various observers during 1902, but which disappeared in 1903. Records are asked for "that will assist in defining the dates of beginning and ending, and the extent of this change in transparency. Such records may consist of photometric or photographic observations of the brightness of the stars; changes in the solar or stellar spectra; unusual prevalence of halos, large Bishop's ring, or haze; observations of heat received from the sun, as made with actinometers or pyrheliometers; observations of the polarization of the blue sky light and of scintillation of the stars. Undoubtedly this diminution and increase of transparency began and ended at different dates in different places, as the phenomena spread gradually over the world during the years 1902 and 1903; additional records are, therefore, desired in order to trace its progress."

Facts bearing upon this subject may be forwarded to Professor Cleveland Abbe at Washington, by whom the circular is signed.

3. *The Alpheus Hyatt Memorial Fund for Field Lessons.*—The report recently issued by the Trustees of the Hyatt Memorial Fund at Boston gives an interesting summary of the field work accomplished during the first year since the organization began. Superintendent Seaver states that 26 teachers from 9 schools have profited by the income of the fund and 2308 children have been taken to the seashore and country. The value of such field work as a part of the education of school children is obvious and it is gratifying to note that the money available produces so large a return. Contributions are asked for in order to increase the endowment; they may be sent to Mr. Stephen H. Williams, 24 Milk st., Boston.

4. *Altitudes in the Dominion of Canada;* by JAMES WHITE, Geographer. Geol. Survey of Canada, Ottawa, 258 pp.—Since 1894 Mr. White has been collecting and classifying data regarding elevations in Canada. Altitudes are given along railroads, rivers and in detail about the Great Lakes and the St. Lawrence. The present volume is the only publication containing this mass of fact and thus becomes a necessary reference book. Four profiles and a relief map of North America accompany the volume.

5. *Publication of the Earthquake Investigation Committee in Foreign Languages.* No. 15. Pp. 72 with eight plates. Tokyo, 1904.—This number is devoted to a discussion by F. OMORI of the application of seismographs to the measurement of the vibration of railway carriages. It gives a detailed account of a series of practical experiments made upon the Government railways of Japan under varying conditions.

6. *Clarkson Bulletin, Vol. I, No. 2,* April, 1904. — This bulletin contains the announcement of the Clarkson School of Technology at Potsdam, N. Y., established in 1896. The second summer session begins July 6, 1904, and extends for six weeks.

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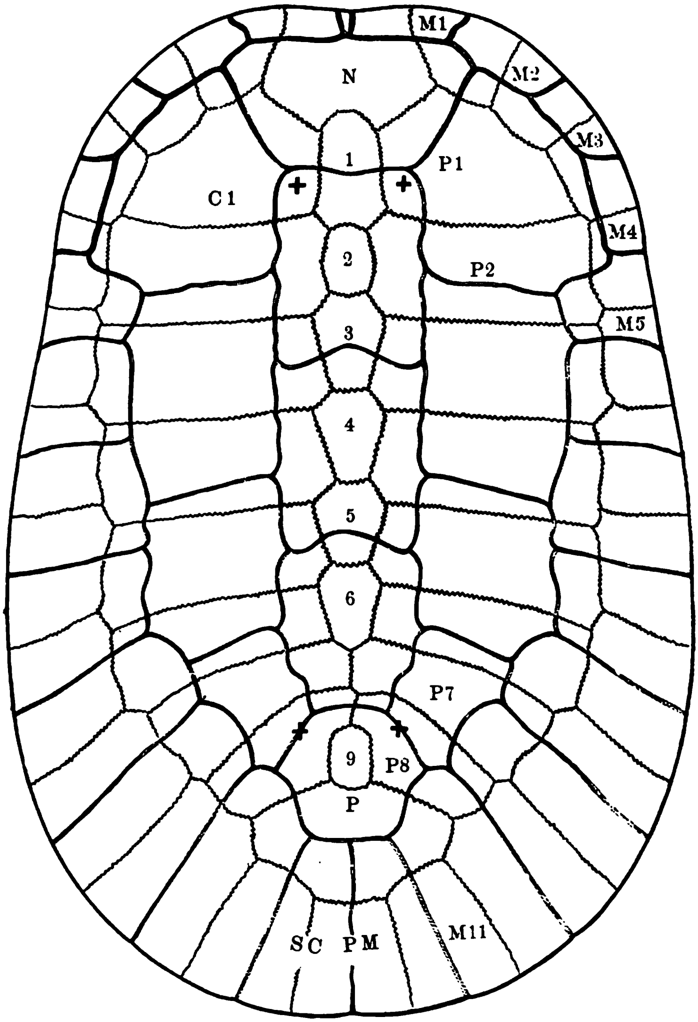


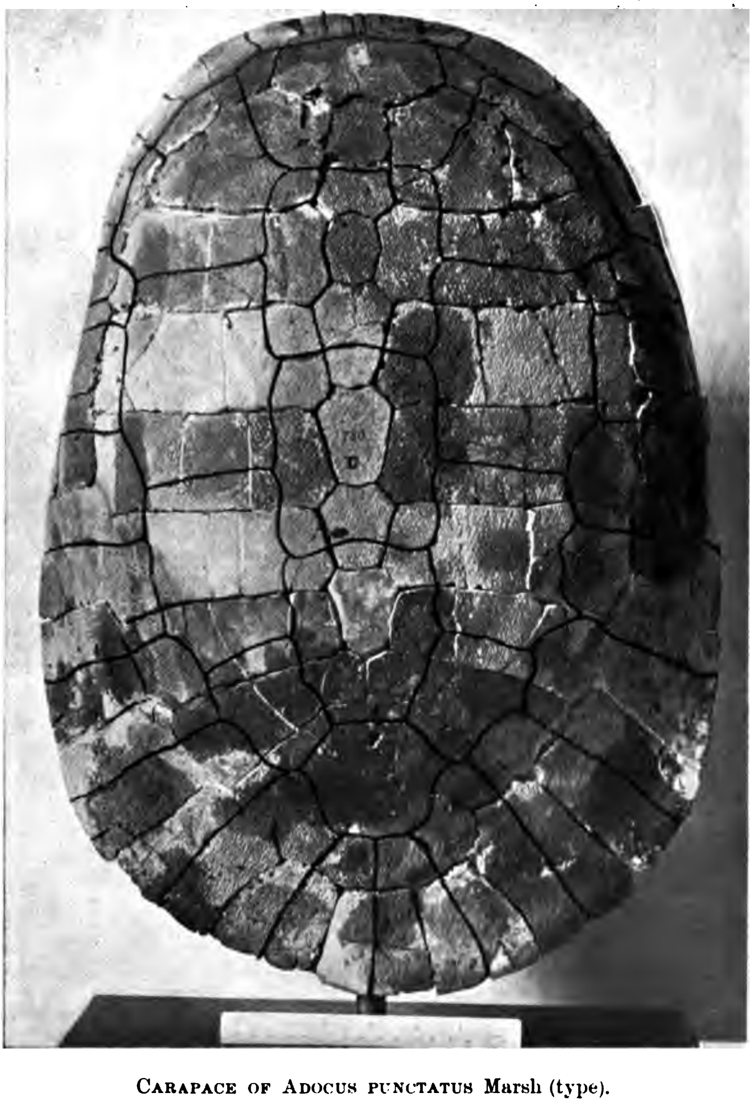
CARAPACE OF ADOCUS PUNCTATUS Marsh, × ½.—Drawn from type.

(a) Bone Plates.—N, Nuchal; 1–6, 9,–1st–6th, and true 9th Neuralia; P, Pygal; Pm, Pygal Marginal; P1, P2, P7, P8,–1st, 2d, 7th and 8th Pleuralia; M1–M5, M11,–1st–5th and 11th Marginals.

(b) Horn Shields. —N and 1, 1st Vertebral; 2 and 3, 2d Vertebral, etc.; C1, the 1st of the four Costals; M1–M5, 1–5 Marginalia; SC, supra caudal.

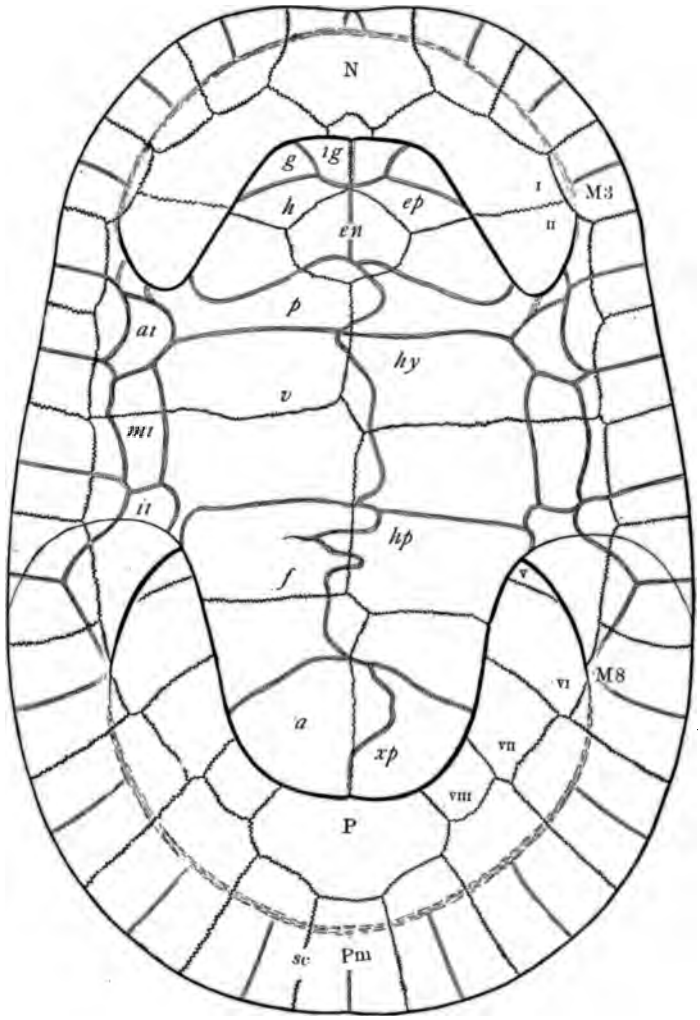
(+) Anterior, point at which the first and second ribs unite with 1st Pleural.

(+) Posterior, point at which rib of tenth dorsal vertebra unites suturally with the 8th Pleural, or else point of iliac support.



CARAPACE OF ADOCUS PUNCTATUS Marsh (type).

(Actual length, 54 cm.)



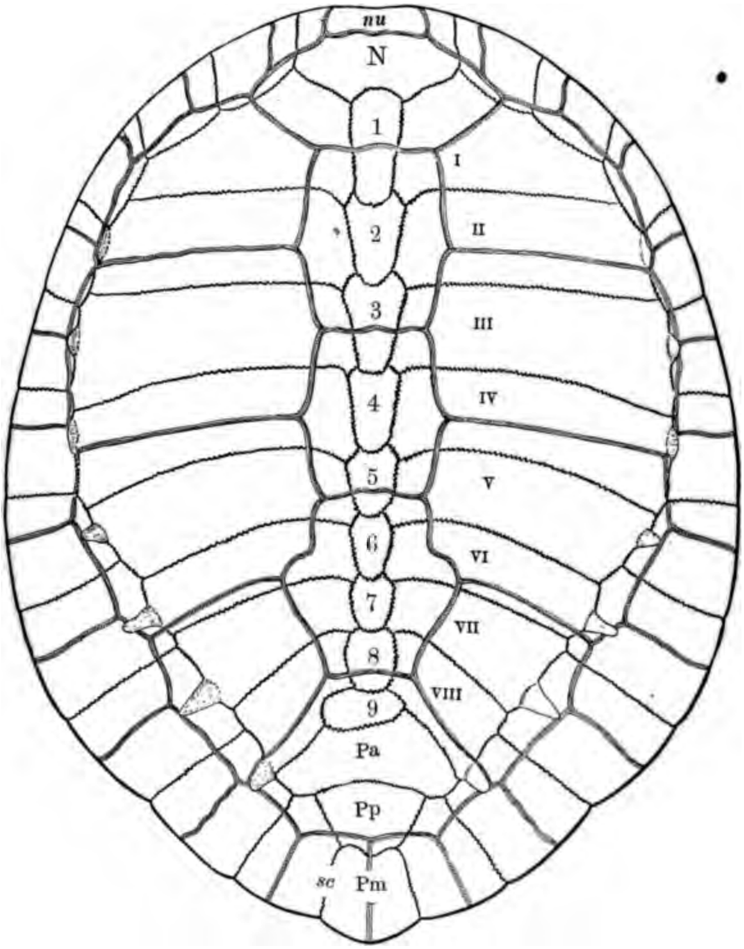
PLASTRAL VIEW OF ADOCUS PUNCTATUS Marsh, × ½.—Drawn from type.

Plastron. — (a) Bone Plates: — *ep*, Epiplastron; *en*, Entoplastron; *hy*, Hyoplastron; *hp*, Hypoplastron: *xp*, Xiphiplastron. (b) Horn Shields:— *ig*, Intergular; *g*, Gular; *h*, Humeral; *p*, Pectoral; *v*, Ventral; *f*, Femoral; *a*, Anal; *ai*, *mi*, *ii*, axillary, mesial and inguinal infra-marginals.

Carapace.—M3, 3d Marginal supporting axillary buttress of Plastron; M8, 8th Marginal supporting inguinal buttress of Plastron; N, Nuchal; P, Pygal; Pm, Pygal Marginal; I, II, V–VIII, 1st, 2d, 5th–8th Pleuralia; *sc*, supracaudal horn shield.

ADOCUS PUNCTATUS Marsh.

Plastral view of type.—Entire length of specimen, 54 cm.

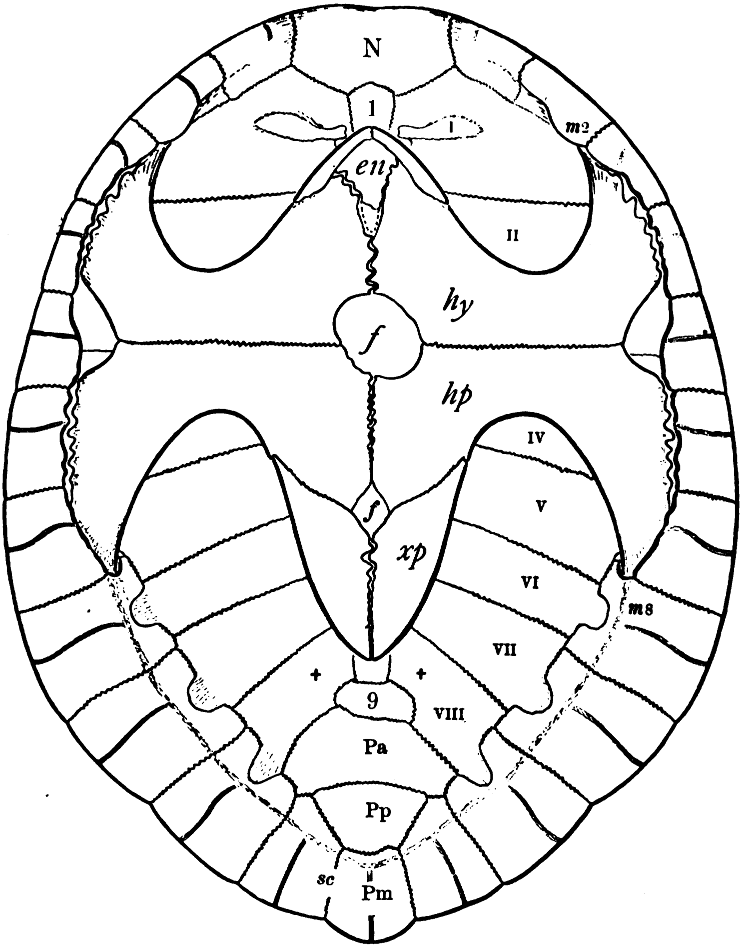


Carapace of Osteopygis Gibbi Wieland, × ⅛.—Drawn from type.

N, Nuchal; 1–9, 1st–9th Neuralia; Pa, Pygal, anterior; Pp, Pygal, posterior; Pm, Pygal Marginal; I–VIII, 1st–8th Pleuralia; *nu*, nuchal horn shield; *sc*, left supracaudal horn shield.—Bony plates in saw-tooth, and horn shields in triple line border.

Carapace of Osteopygis Gibbi Wieland (type).

Actual length, 74.3 cm.



PLASTRAL VIEW OF OSTEOPYGIS GIBBI Wieland, $\times \frac{1}{8}$.—Drawn from type.

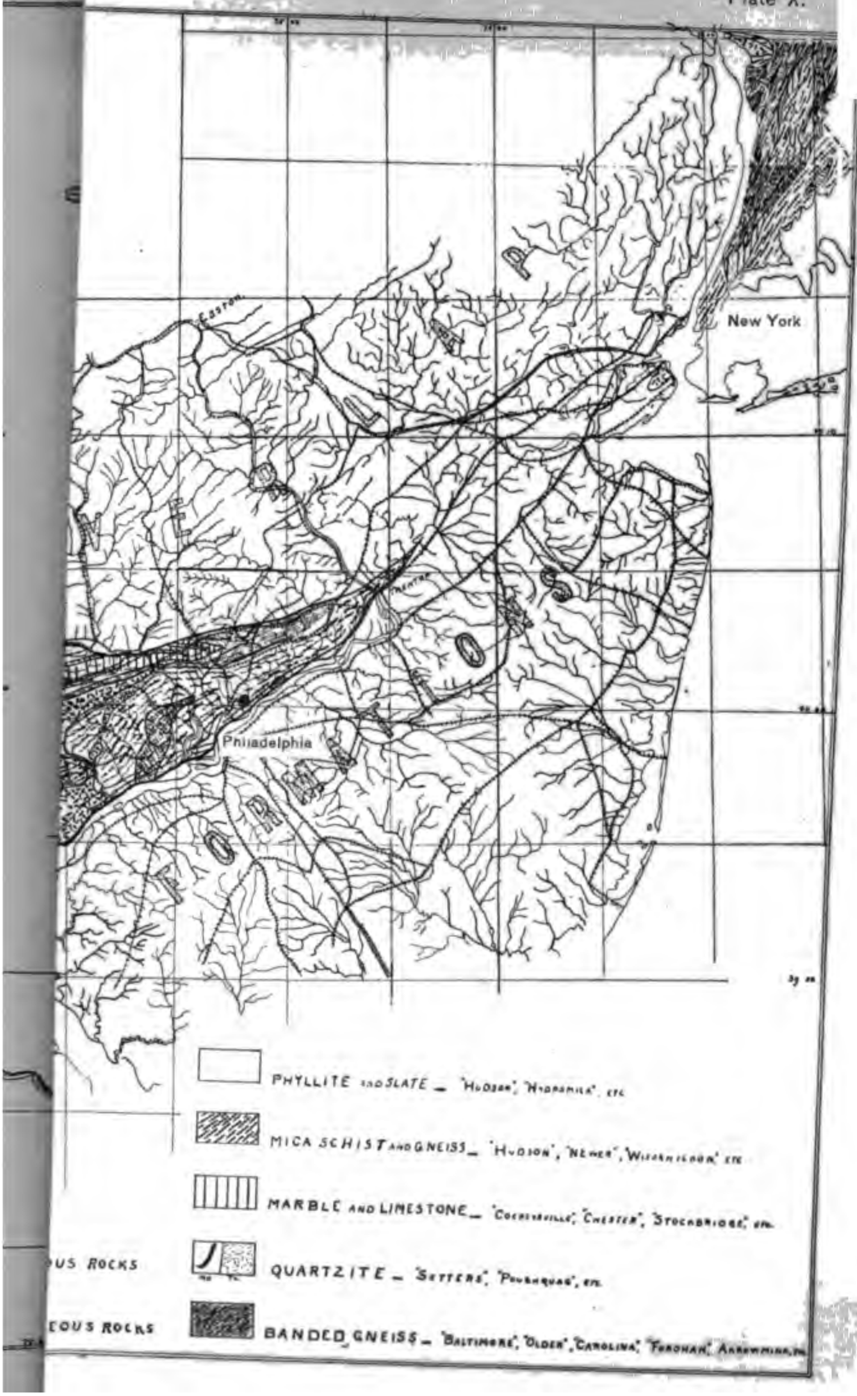
en, Entoplastron; *hy*, Hyoplastron; *hp*, Hypoplastron; *xp*, Xiphiplastron; *f*, *f*, Plastral Foramina; *m2*, axillary buttress and 2d Marginal; *m8*, inguinal buttress and 8th Marginal; N, Nuchal; 1, 9, 1st and 9th Neurals; Pa, Pygal, anterior; Pp, Pygal, posterior; Pm, Pygal Marginal; I, First Rib; II, IV–VIII, Pleuralia; (+), point of iliac support on 8th pleural; *sc*, supracaudal horn shield.

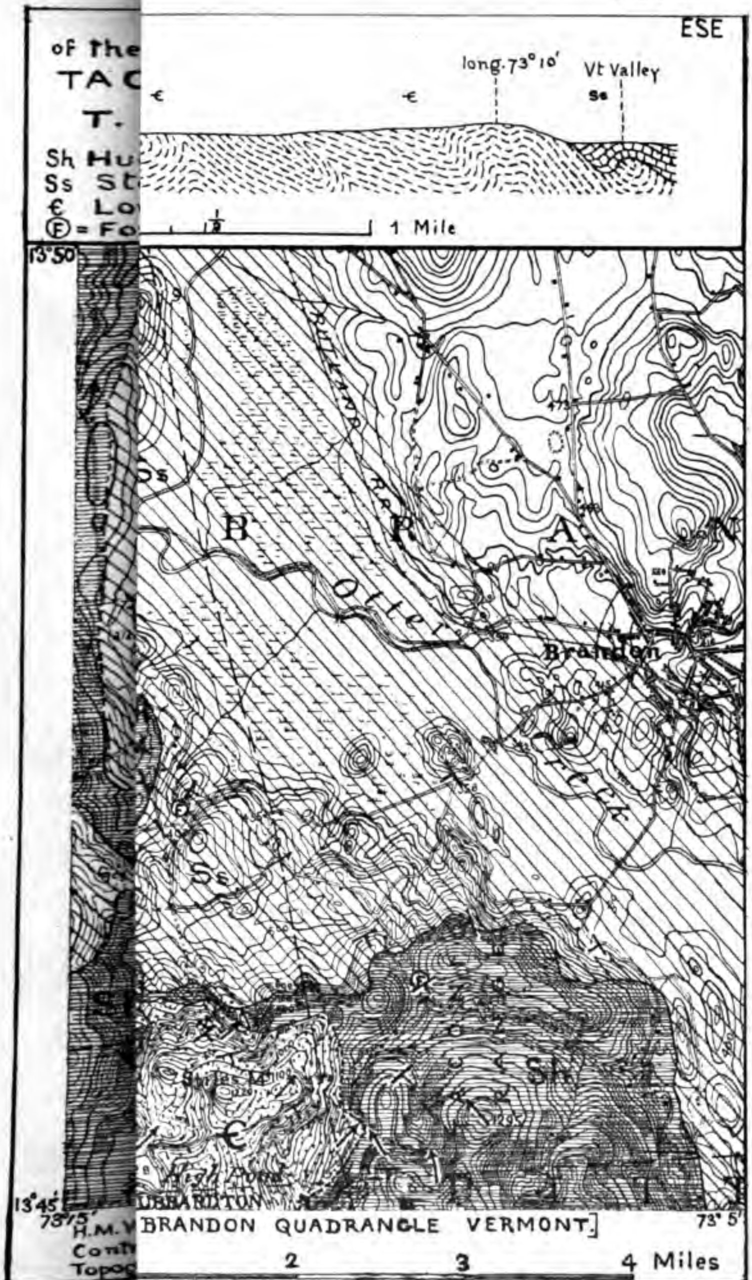
Osteopygis Gibbi Wieland.

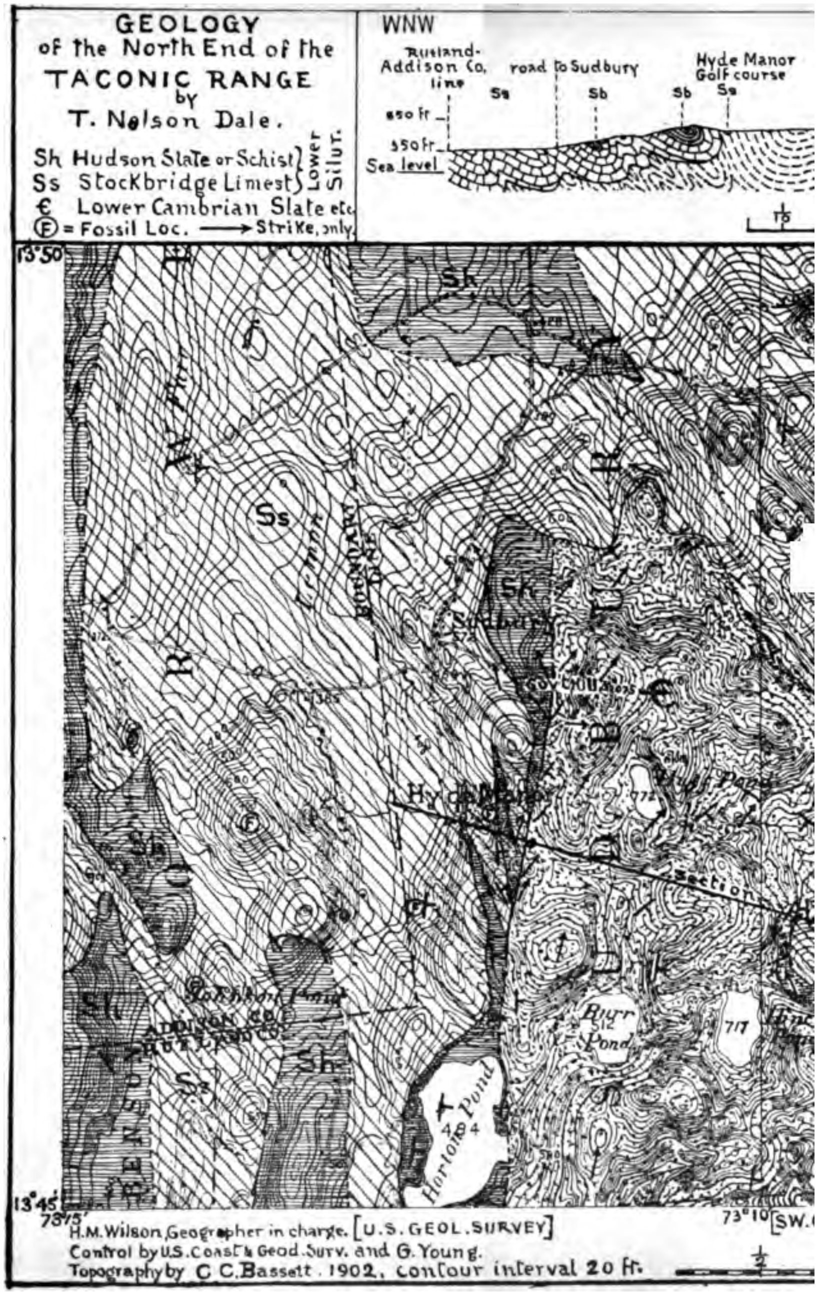
Plastral view of type.—Entire length of specimen, 74.3 cm.

PROPLEURA BOREALIS, sp. nov. × $\frac{1}{6}$.

N, Nuchal; 1, 2,—1st and 2d Neurals; Lm 1–3, 5, 6.—Left Marginals; M2, 3, 5–7,—Right arginals; R. P. 1, 2, 4, 5.—Right Pleurals; L. P 1, 3,—Left Pleurals; H, Hyoplastron; p. Hypoplastron: X, X,—Xiphiplastra; L H, Left Humerus (dorsal view); P, Pubis; Il, ium; Is, Ischia.—Nuchal, and 1st and 2d vertebral horn shields, in ink outline.

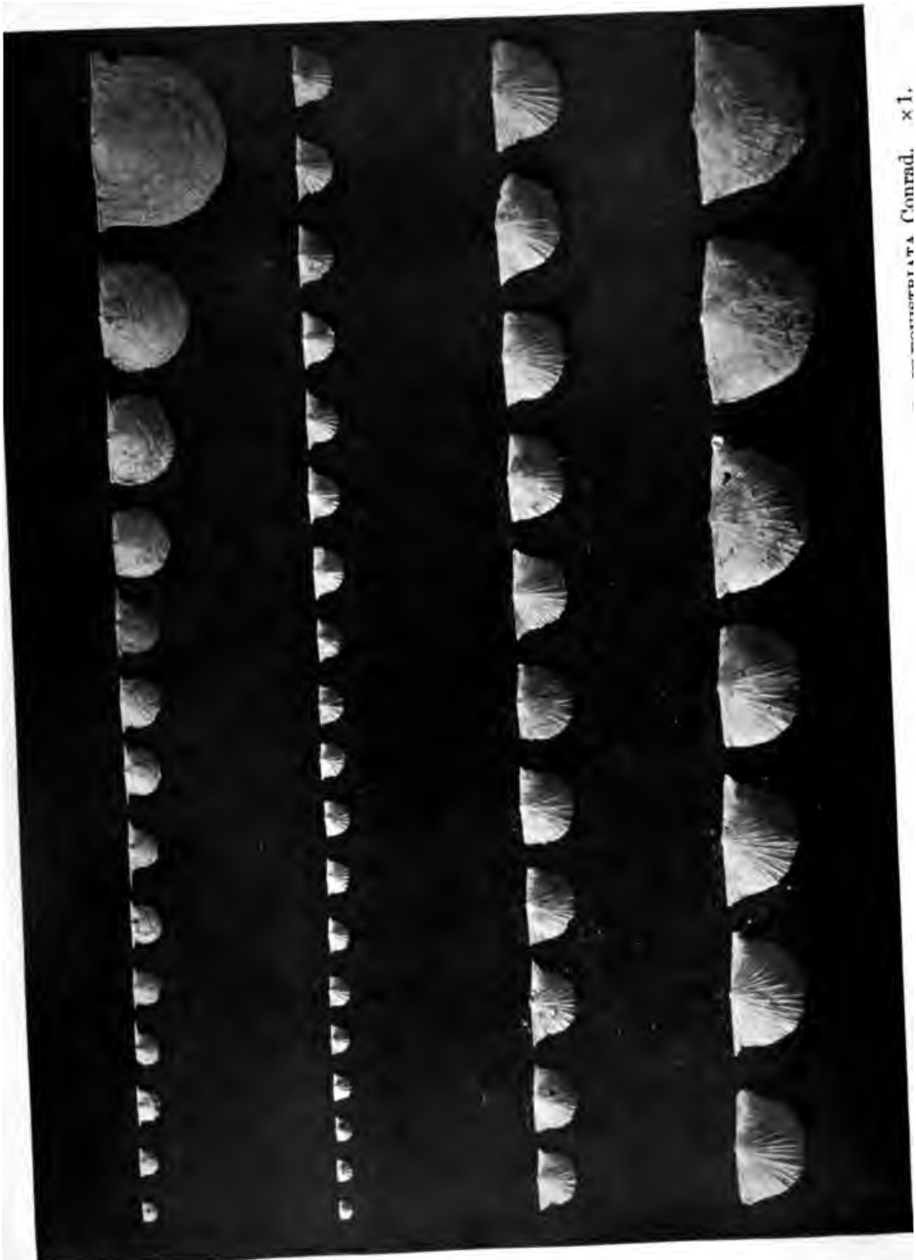

Easton
Trenton
New York
Philadelphia
PHYLLITE AND SLATE — "Hudson", "Hydromica", etc.
MICA SCHIST AND GNEISS — "Hudson", "Newer", "Wissahickon", etc.
MARBLE AND LIMESTONE — "Cockeysville", "Chester", "Stockbridge", etc.
QUARTZITE — "Setters", "Poughquag", etc.
BANDED GNEISS — "Baltimore", "Older", "Carolina", "Fordham", Arrowmink, etc.
US ROCKS
EOUS ROCKS


ESE
long. 73° 10′
Vt Valley
1 Mile
Ss
Brandon
Otter Creek
Sh
BRANDON QUADRANGLE VERMONT]
73° 5′
2
3
4 Miles


GEOLOGY
of the North End of the
TACONIC RANGE
by
T. Nelson Dale.
Sh Hudson Slate or Schist
Ss Stockbridge Limest
Lower Silur.
€ Lower Cambrian Slate etc
(F) = Fossil Loc. ⟶ Strike, only
WNW
Rutland-Addison Co. line
road to Sudbury
Hyde Manor Golf course
850 ft
350 ft
Sea level
Ss
Sh
Sudbury
Hyde Manor
Section
Burr Pond
Horton Pond
484
717
Addison Co.
Rutland Co.
13°50'
13°45'
73°15'
73°10'
H.M. Wilson, Geographer in charge. [U.S. GEOL. SURVEY]
Control by U.S. Coast & Geod. Surv. and G. Young.
Topography by C.C. Bassett. 1902, contour interval 20 ft.

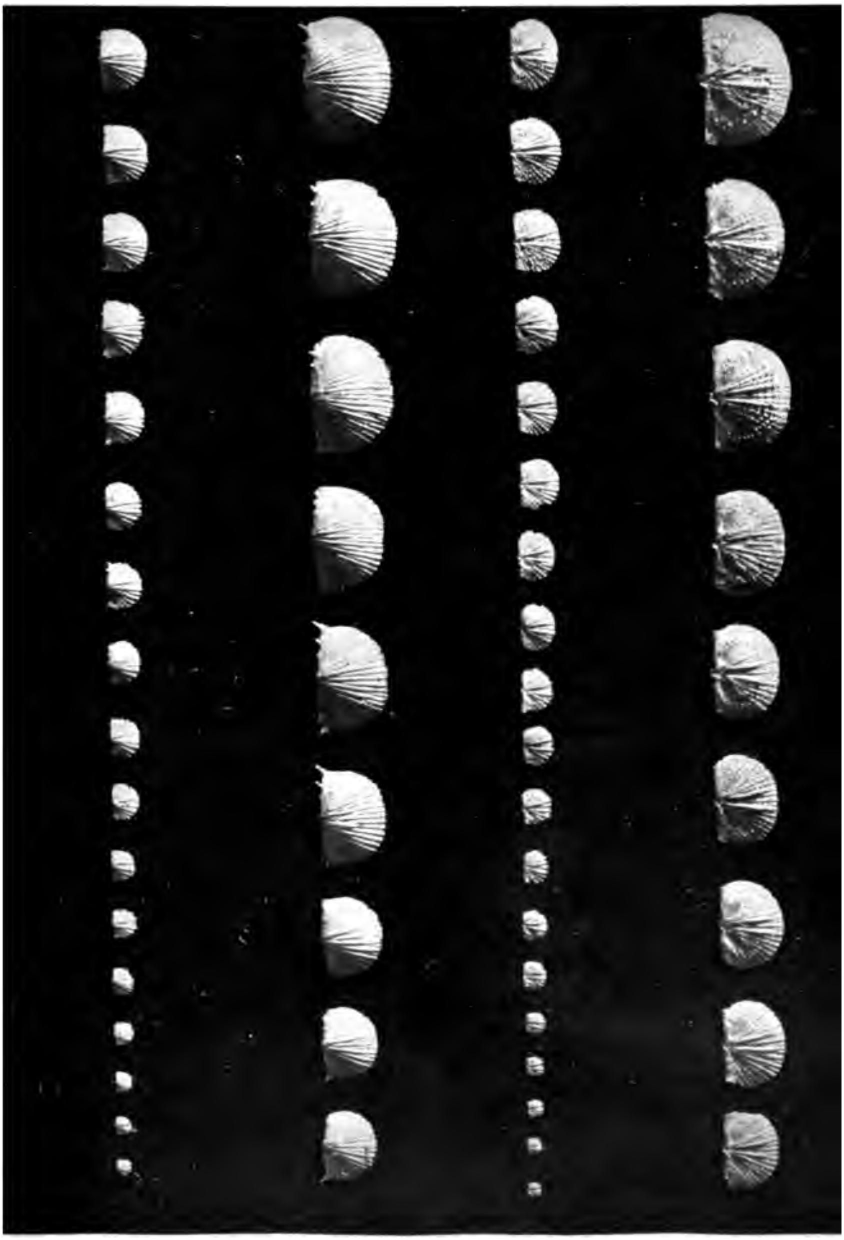
Am. Jour. Sci., Vol. XVII, 1904.

Plate XIII.

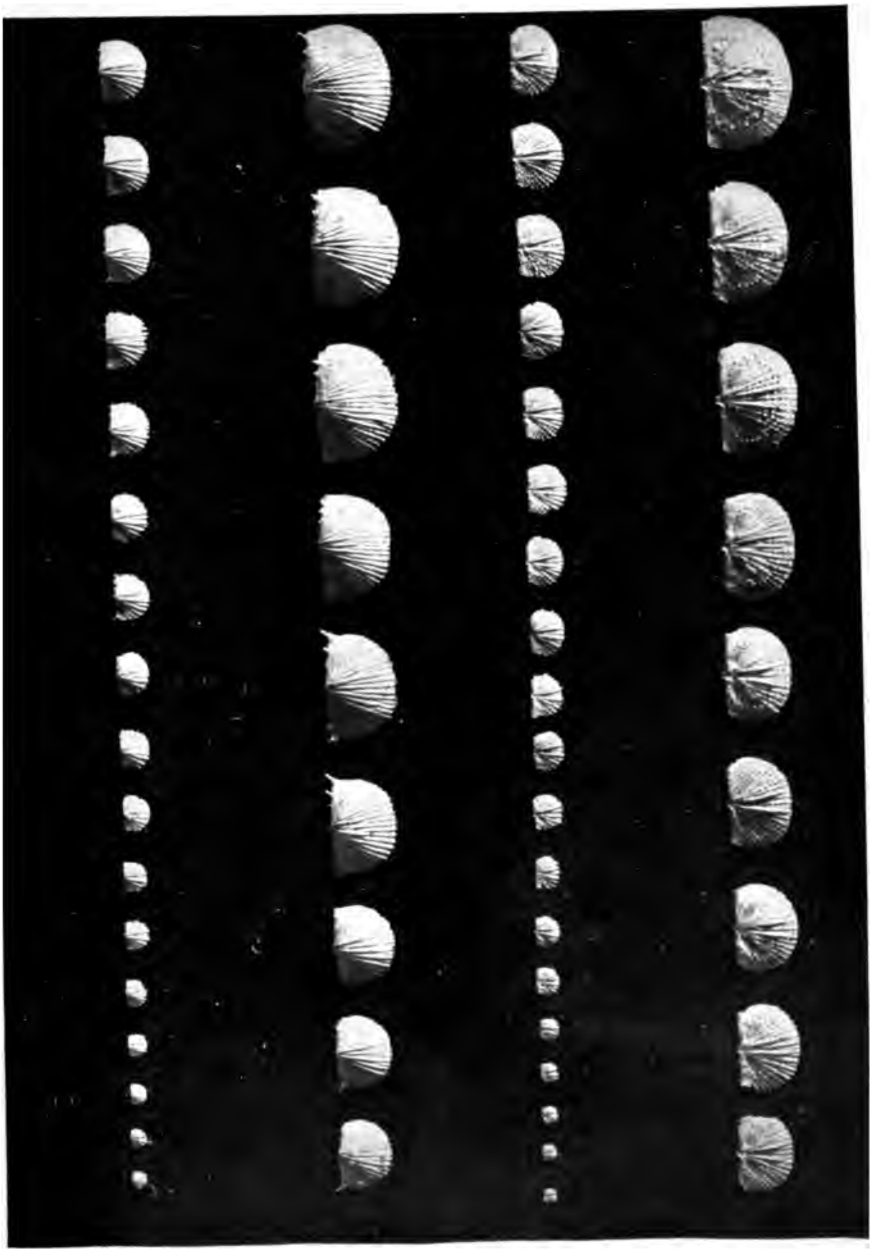


1 2 3 4

...TRIATA Conrad. × 1.



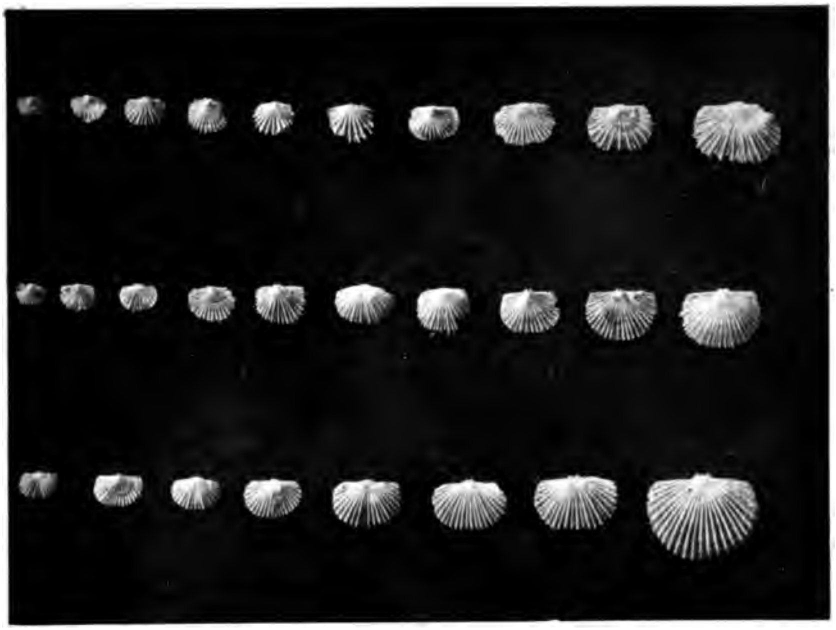
1 2 3 4



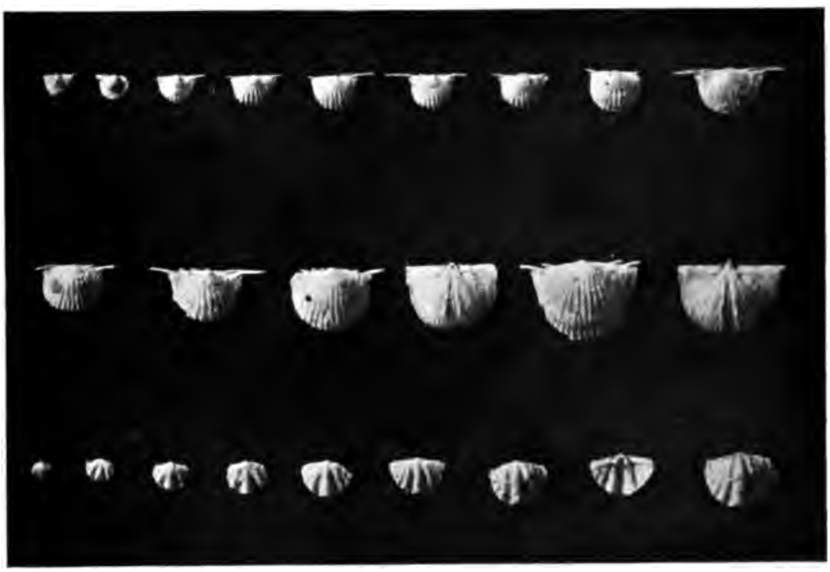
1 2 3 4

CHONETES SCITULUS Hall. × 2.

1
2
3



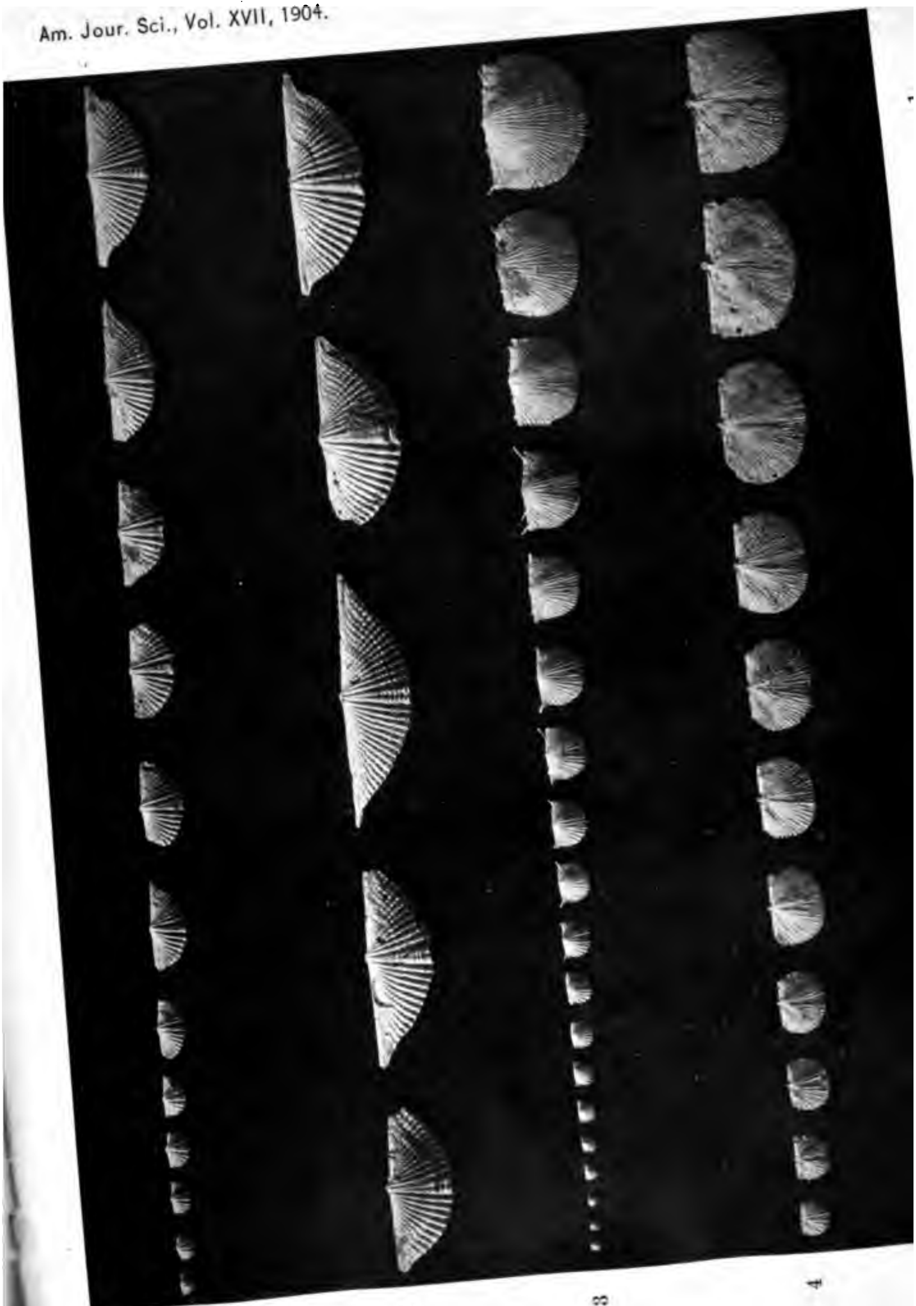
4
5
6



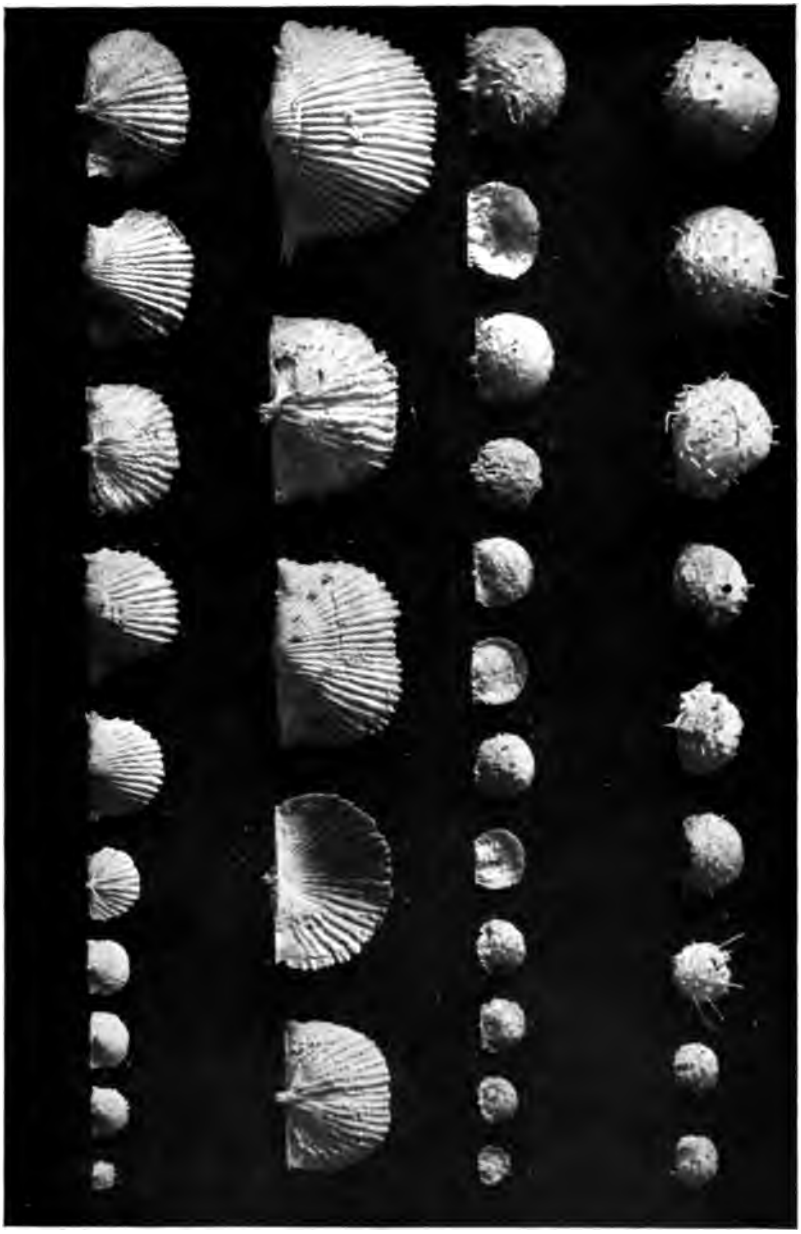
1.—Orthothetes chemungensis var. pectinacea Hall. ×2.
2.—Orthothetes chemungensis var. arctistriatus Hall. ×2.
3.—Orthothetes bellulus Clarke. ×2.
4, 5.—Chonetes mucronatus Hall. ×2.
6.—Cyrtina hamiltonensis Hall. ×2.

Plate XVI.

Am. Jour. Sci., Vol. XVII, 1904.

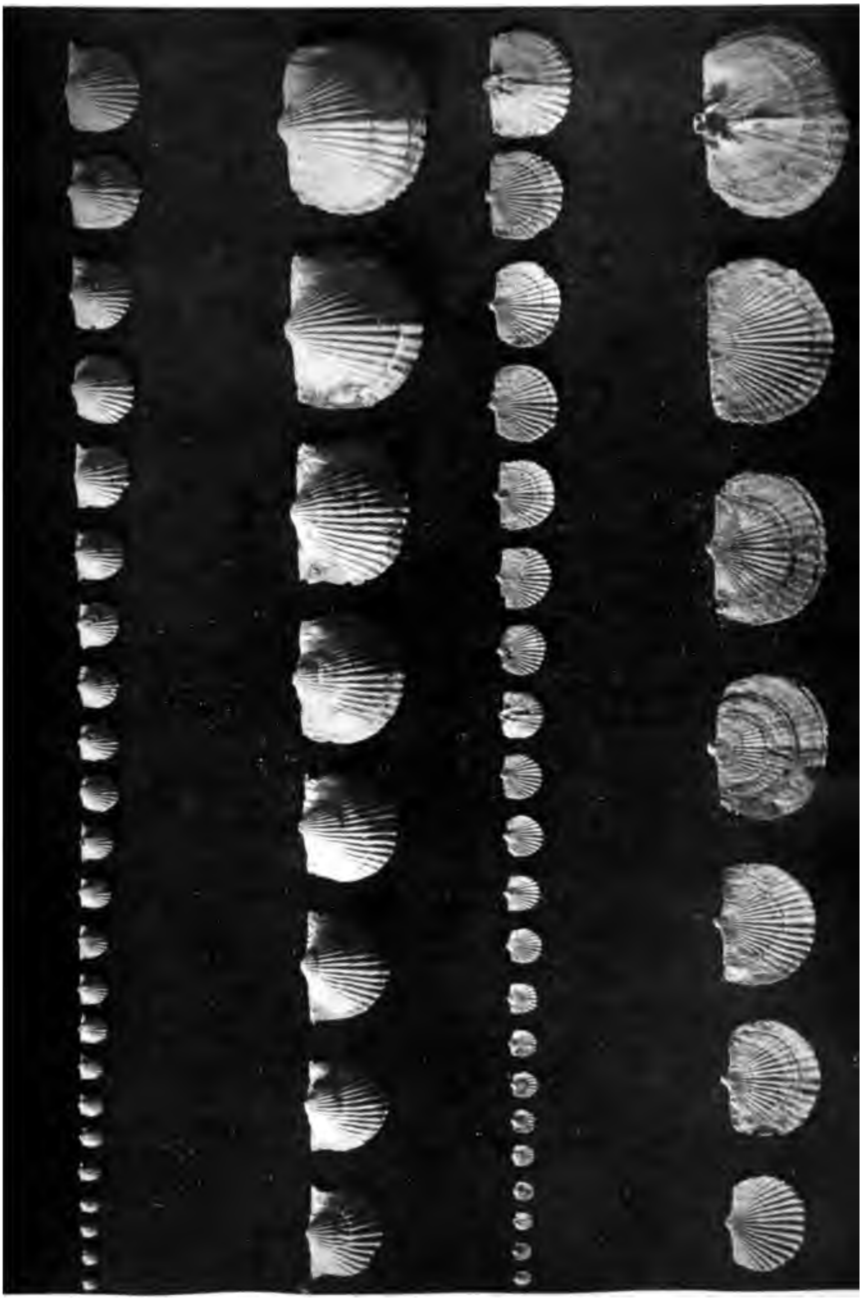


1 2 3 4

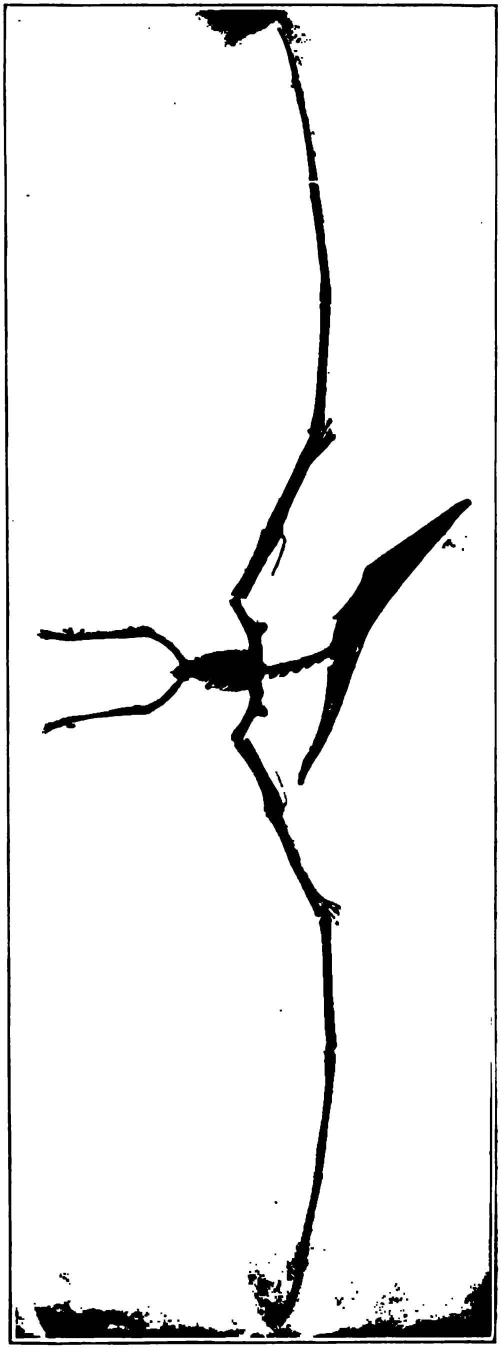


1 2 3 4

1, 2.—Chonetes robustus Raymond. ×2. 3, 4.—Strophalosia truncata Hall. ×2.

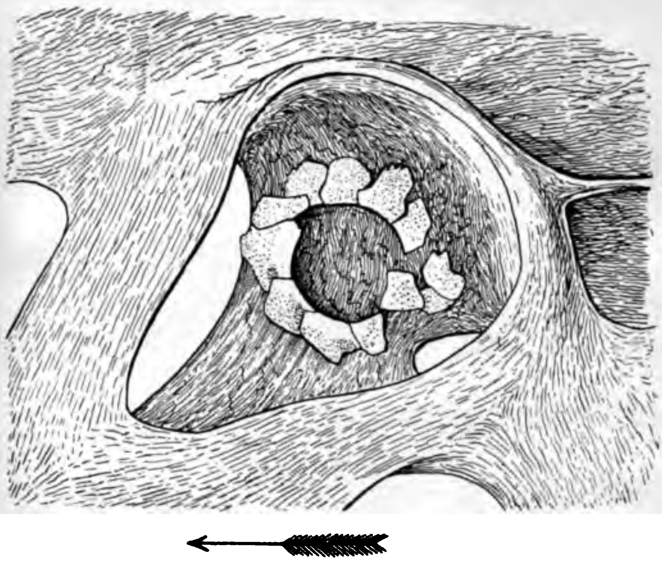


1 2 3 4

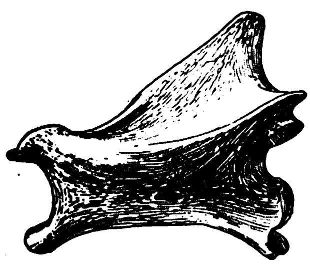


Restoration of PTERANODON LONGICEPS Marsh.
One twenty-fourth natural size.

1



2



3

4

5

6

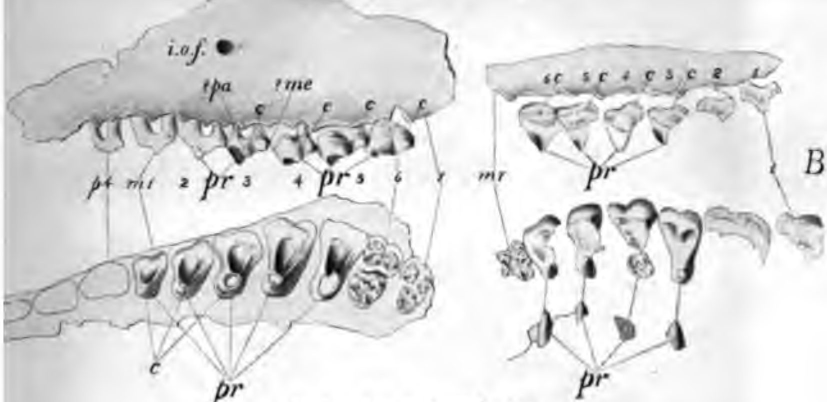
7

8

PTERANODON Marsh.

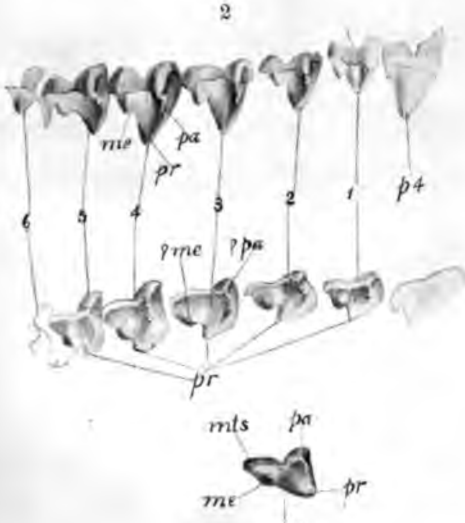
1

External or maxillary view.

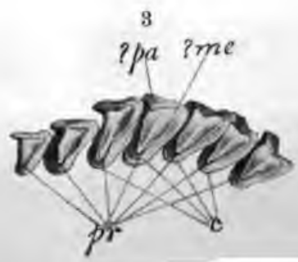


Palatal or internal view.

2

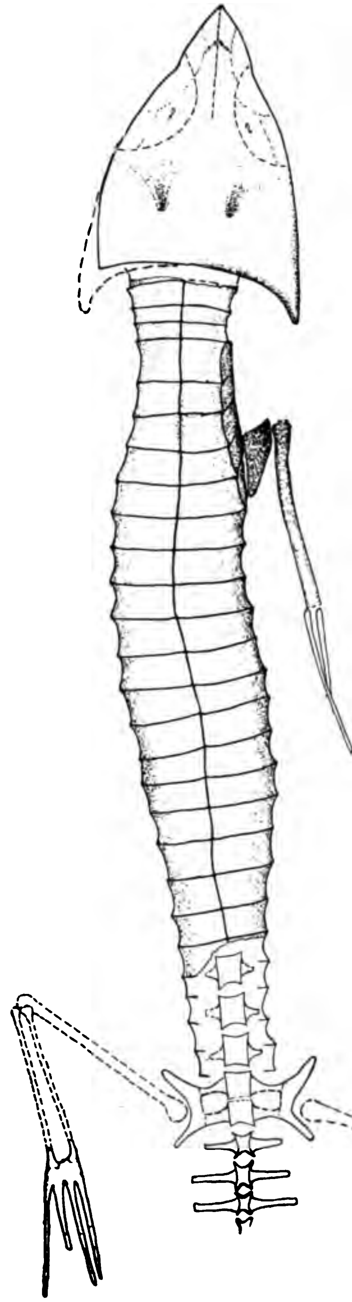


3



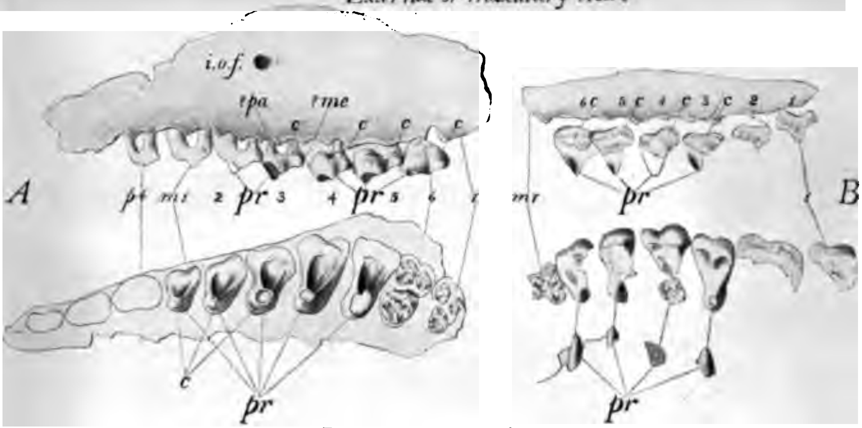
1

2



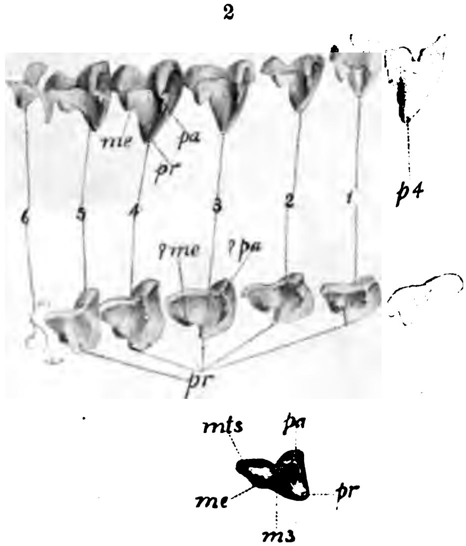
1

External or maxillary view.



Palatal or internal view.

2



3

1

2

3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